Evolution of capabilities in agribusiness:
The case of the Mexican dairy sector

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I hereby declare that this thesis has not been and will not be, submitted in whole or in part to another University for the award of any other degree:

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Guadalupe del Rocío Alvarez Tinoco DPhil in Science and Technology Policy Studies

EVOLUTION OF CAPABILITIES IN AGRIBUSINESS: THE CASE OF THE MEXICAN DAIRY SECTOR

SUMMARY

The aim of this thesis is to investigate how capabilities are created, accumulated and evolved as dairy farmers and dairy processors interact with other actors (e.g. suppliers, government organisations, research organisations, universities, MNCs, etc.) in three Mexican dairy regions in the Mexican dairy sector (MDS). The MDS plays an important part in mitigating the social problem of malnutrition in low-income families and reducing peasant migration. In particular, this thesis analyses the processes of capabilities building to integrate the value chains of those firms in complex socio-economic and technological systems. In these processes, regional actors, their networks and institutions have played major interdependent roles during globalisation following the signing of the North American Free Trade Agreement, NAFTA (i.e. 1994-2004), which ended a long period of imports substituting industrialisation regime.

This thesis proposes the concept of sector-specific regional capabilities (i.e. regional capabilities) and an analytical framework based on this concept in order to fill gaps in the literature on evolutionary economics, firm, organisation and strategy and regional innovation systems. The thesis investigates the integration of the micro (firms) and meso (regions) levels of capabilities development in agribusiness in a developing context. The research builds upon four main theoretical approaches: 1) dynamic capabilities of firms; 2) regional system of innovation, including regional capabilities, 3) sectoral systems of innovation; and 4) a function-based approach to comparing regional performance in capabilities building aimed at improving policy making. By combining elements of these approaches, this research articulates the logic of the coevolution of routines into improved and new capabilities within farms and dairy processors (i.e. intra-organisational capabilities) and between these actors and other organisations (i.e. inter-organisational capabilities), which carried out collective activities and processes involving learning.

A cross case research employed involved a set of 120 in-depth interviews with the main actors in three dairy regions, which differ in climatic conditions, socio-economic features and the technology of their milk production systems. Interviews were designed to identify and assess (qualitatively) the interactions that led the processes and development mechanisms that changed routines, which provide the basis for new and improved capabilities, as well as the factors that constrained their development. Secondary data from research of academics and practitioners provided complementary evidence related to the operation of government programmes affecting the MDS.

This research shows that sector-specific regional capabilities are built as the result of the learning that occurs when firms and different organisations interact in formal and non-formal transactions. Regional capabilities comprise intra organisational capabilities (i.e. dynamic capabilities) (e.g. R&D, marketing capabilities, etc.), and inter organisational capabilities (e.g. production, alliance-making, research capabilities, etc.), which are shown to coevolve over time with regional institutions influencing this co-evolution process.

Comparison shows that the creation, accumulation and evolution of regional capabilities using a specialised milk production system between the three dairy regions is markedly different. Regional capabilities in La Laguna region became strategic, allowing regional firms to reach national and international markets. Firms in the Los Altos region accumulated operational capabilities and are in transformation, not yet reaching national and international markets comparable to La Laguna firms. Firms in the Tabasco region accumulated basic capabilities and still lags behind the other two regions. These results have implications for improving policy making. National policies should be tailored by regional dimensions to develop small dairy farms and firms capabilities in all regions. Regional institutions with targeted policies may help regions obtain and develop resources to build capabilities and remove constraints for long-term sustainability in the dairy regions.

List of Tables

List of Figures

List of supplementary Tables

List of Acronyms

AGLO	Local cattlemen association of Ozuluama (Asociación Ganadera Local de Ozuluama, Veracruz)
AGLOj	Local cattlemen association of Ojuelos (Asociación Ganadera Local de Ojuelos, Jalisco)
AGLUSA	Local cattlemen association of Unión de San Antonio (Asociación Ganadera Local de Unión de San Antonio, Jalisco)
AGLLM	Local cattlemen association of Lagos de Moreno (Asociación Ganadera Local de Lagos de Moreno, Jalisco)
Asociación Holando Cebú	Milk farmers association for breeding Holland and Zebu bovines
AMMVEB	Civil association of veterinarians specialised in bovines (Asociación Mexicana de Médicos Veterinarios Especialistas en Bovinos, A.C.)
ANGLAC	Civil association representing the national dairy farmers (Asociación Nacional de Ganaderos Lecheros A.C.)
BANRURAL	Bank to support rural development
CECAREM	Training centre for minor species production (Centro de Capacitación y Reproducción de Especies Menores)
CAGR	Compound annual growth rate
CEBETIS	College for industrial and services studies (Centro de Bachillerato Industrial y de Servicios)
CECyT Tabasco	Tabasco science and technology council (Consejo Estatal de Ciencia y Tecnología de Tabasco)
CEMVZV	College of veterinarians and zootecnists of Veracruz (Colegio Estatal de Médicos Veterinarios Zootecnistas de Veracruz)
CIESAS	Research centre for higher education in social anthropology (Centro de Investigaciones y Estudios Superiores en Antropología Social)
CIESTAAM	Economic, social and technological research centre for the world agriculture and agro industry (Centro de Investigaciones Económicas, Sociales y Tecnológicas de la Agricultura y la Agroindustria Mundial)
CIGAL	Internacional conference for dairy cattle (Conferencia International sobre Ganado Lechero)
CIPEJ	Livestock research centre of Jalisco state (Centro de Investigaciones Pecuarias del Estado de Jalisco)
CNOG	National confederation of cattlemen organisations (Confederacion Nacional de Organizaciones Ganaderas)
COFOCALEC	Development council for the quality of milk and dairy products (Consejo para el fomento de la Calidad de la Leche y sus Derivados, A.C.)
COFUPRO	Patronage for agriculture research (Patronato de Apoyo a la Investigacion Agropecuaria)
CONACYT	Mexican national council for science and technology (Consejo Nacional de Ciencia y Technología)
CONALEP	College for technical professional education (Colegio Nacional de Educación Profesional Técnica).
CFPPET	Committee for the development and protection of Tabasco livestock (Comité para el Fomento y Protección Pecuaria del Estado de Tabasco, S.C.).
COLPOS Cárdenas	Tabasco postgraduate research unit at 'Universidad Autónoma de Chapingo' at Cárdenas in Tabasco (Colegio de Postgraduados en Ciencias Agrícolas Campus Tabasco).
CSPBL	Committee for the system of milk and dairy production (Comité para el Sistema Producto Bovino Leche), part of SAGARPA
DCyREMA	Direction for training and animal reproduction and fisheries of Tabasco government (Dirección de Capacitación y de Reproducción de Especies Menores y Acuícolas)
DIF	Family integrated development programme (Desarrollo Integral de la Familia)
DIGAL	International day for dairy farmers (Día Internacional del Ganadero Lechero)
DGN	National organisation for norms (Dirección General de Normas)
EMA	Mexican entity for accreditation (Entidad Mexicana de Acreditación)
FAO	Food Agriculture Organisation

FIRA	Trusteeship for the agriculture sector is part of the central bank, Banco de México (Fideicomisos Instituídos para la Agricultura)
FIRCO	Trusteeship for risk sharing (Fideicomiso de Riesgo Compartido)
Financiera Rural	Bank to support rural development (previously BANRURAL)
Fundación Produce Jalisco, FUNPROJAL	Civil association for Jalisco agricultural development, part of COFUPRO
Fundación Produce La Laguna	Civil association for La Laguna agricultural development, part of COFUPRO
Fundación Produce Tabasco	Civil association for Tabasco agricultural development, part of COFUPRO
Fundación Tabasco	Civil association for Tabasco development
'Ganaderos'	Cooperative for livestock inputs (Cooperativa de Consumo 'Ganaderos')
GATT	General Agreement on Tariffs and Trade
GEMEX	Suppliers of inputs for milk production (Genética Mexicana)
GERSSE	Economic Group of the South and South-eastern Region (Grupo Económico de la Región Sur-Sureste)
GGAVATT	Cattle farmers groups for the validation and transfer of livestock technology (Grupo de Ganaderos de Validación y Transferencia de Tecnología Pecuaria)
IFPRI	International Food Policy Research Institute
IIE	Research institute for economics (Instituto de Investigaciones Económicas, UNAM)
IIS	Research institute for sociology (Instituto de Investigaciones Sociales, UNAM)
INIFAP	National Research Institute for Forestry, Agriculture and Livestock (Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias)
IS	Innovation system
ITA No. 28	Agricultural technology institute No. 28 (Instituto Tecnológico Agropecuario No. 28)
ITESM	Monterrey technological institute of higher education (Instituto Tecnológico y de Estudios Superiores de Monterrey)
ITH	Humid tropical institute (Instituto del Trópico Húmedo)
ITV	Technology institute at Villahermosa in the state of Tabasco (Instituto Tecnológico de Villahermosa).
JAMALAC	A dairy firm in Jamapa in the state of Veracruz (Grupo Agropecuario y Forestal Jamapa, SC de RL de CV)
LICONSA	State firm to which re-hydrates NFDM and distributes through out CONASUPO shops under a social programme (Leche Industrializada CONASUPO)
LDM	A cheese producer in Lagos de Moreno in the state of Jalisco (Lácteos Deshidratados Mexicanos)
NAFTA	North America Free Trade Agreement
ONNSPBL	National organisation to standardise the committee for the system of milk and dairy production (Organismo Nacional de Normalización del Sistema Producto Bovino Leche)
EMA	Mexican entity for accreditation (Entidad Mexicana de Acreditacion)
PALN	LICONSA programme to acquire national milk since 2002 (Programa de Adquisición de Leche Nacional)
PDO	Protected Designation of Origin
PIAL	Patronage for the research in dairy livestock production in La Laguna (Patronato para la Investigación Agropecuaria Lechera de La Laguna)
PROCAMPO	Direct policy subsidy to farmers (Programa de Apoyo para el Campo)
PRODEVIT	Project to improve the diagnostic services for livestock in the state of Jalisco (Proyecto para el Mejoramiento de los Servicios Regionales de Diagnóstico Veterinario del Estado de Jalisco)
PROFECO	Federal government agency in charge of the enforcement of the law to defend the consumers' rights (Procuraduría Federal del Consumidor)
PROFELET	Development dairy program in the tropical areas (Programa de Fomento Lechero Tropical)
PROFEPA	Mexican environmental prevention agency (Procuraduría Federal de Protección al Ambiente)

PROGAN	Support programme to promote the livestock productivity (Programa de Estímulos para la Productividad Ganadera)
PROLEA	A dairy farmers association in Acatic in the state of Jalisco (Productores de Leche de Acatic)
PROTAL	Programme aiming at reaching milk self-sufficiency (Programa de Transición hacia la Autosuficiencia Lechera, 1989)
PLSI	Programme to promote the production of milk and to sustitute the imports of non fat dry milk (NFDM) (Programa de Producción de Leche y de Sustitución de Importaciones, 1996-2000)
R&D	Research and Development
RIS	Regional Innovation System
SAGAR	Secretariat of agriculture, livestock and rural development. (Secretaría de Agricultura, Ganadería y Desarrollo Rural)
SAGARPA	Secretariat of agriculture, livestock, rural development, fisheries and food (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación)
S&T	Science and Technology
SEDAFOP	Secretariat for the development of agriculture, livestock, forestry and fisheries of the state of Tabasco (Secretaria de Desarrollo Agropecuario, Forestal y Pesquero)
SEDER	Secretariat of rural development (Secretaría de Desarrollo Rural)
SEDESOL	Secretariat of social development (Secretaría de Desarrollo Social)
SENASICA	National services for health, safety and quality for the of agro food industry (Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria)
SIAP	Information service for agriculture, food and fisheries (Servicio de Información Agroalimentaria y Pesquera)
SINIIGA	National system for animal livestock identification (Sistema Nacional de Identificación Individual de Ganado)
SNI	National system of researchers (Sistema nacional de investigadores)
SNIA	Mexican system of agricultural research (Sistema Nacional de Investigación Agrícola)
SARH	Secretariat of agriculture and water resources (Secretaria de Agricultura y Recursos Hidráulicos)
SOMEXAA	Mexican Association for Agribusiness Management (Sociedad Mexicana de Administración Agropecuaria)
UAAAN	Autonomous agrarian university Antonio Narro (Universidad Autónoma Agraria Antonio Narro)
UACh	Autonomous university of Chapingo (Universidad Autónoma de Chapingo)
UCIALSA	Agriculture and dairy industrial development credit union (Unión de Crédito Industrial y Agropecuario de La Laguna, SA de CV)
UGRNV	Regional cattlemen association of the North of Veracruz (Unión Ganadera Regional Norte de Veracruz)
UGRSV	Regional cattlemen association of the South of Veracruz (Unión Ganadera Regional Sur de Veracruz)
UGRCEV	Regional cattlemen association of the Centre of Veracruz (Unión Ganadera Regional Centro del Estado de Veracruz)
UCG Tabasco	Cattle farmers credit union of Tabasco (Unión de Crédito Ganadero de Tabasco).
UGR Tabasco	Regional cattle farmers association of Tabasco (Unión Ganadera Regional de Tabasco)
UJAT	Juárez autonomous university of Tabasco (Universidad Juárez Autonóma de Tabasco)
UNAM	Autonomous national university of Mexico (Universidad Nacional Autónoma de México)
UPCh	Chontalpa Popular University (Universidad Popular de la Chontalpa).
UTT	Technological university of Tabasco (Universidad Tecnológica de Tabasco)

Chapter 1. Introduction

The vast literature on capabilities development is based upon a common agreement regarding the importance of capabilities for the long-term sustainable economic growth of any single unit of analysis from the micro level, firms and more generally organisations, the meso level, industries and regions, and the macro level, countries (von Tunzelmann 2009a). This literature comes from two main strands of evolutionary economics (as that field was defined by Nelson and Winter 1982), the innovation systems (Freeman 1987; Lundvall 1992; Nelson 1993) and the resource based view of firm, organisation and strategy (Penrose 1995).

The approach to capabilities in innovation studies emphasises that technological capabilities development is a core process for developing countries to catch up economic growth (Bell 1984; Lall 1992; Bell and Pavitt 1993; Lall 1993; Bell and Pavitt 1995; Hobday 1996; Lall 1998). Much of the research concerning developing economies has focused on manufacturing systems and high tech sectors, in which mobilisation and accumulation of knowledge, resources and capital have been faster than in traditional sectors, e.g. agribusiness, mining, wood and paper, etc.

With respect to knowledge accumulation, the regional innovation system literature has hypothesised that the creation of unique capabilities and products depends on the production and use of tacit knowledge (Maskell and Malmberg 1999). The focus on tacit knowledge in regional innovation systems is based on the premise that tacit knowledge is not easy to exchange over long distances. Such knowledge is produced in specific contexts under socially organised learning processes carried out through interactions and knowledge flows between firms, research organisations and public organisations (Gertler 2003; Asheim and Gertler 2005). In this literature, tacit knowledge is assumed to be the result of interactions between firms with other organisations that involve learning processes (Asheim and Gertler 2005). The same argument is made concerning national innovation systems (Freeman 1987; Lundvall 1992; Nelson 1993) and greater stress in that literature is given to institutions (i.e. rules, norms and standards) governing knowledge exchange processes. Although both strands of literature recognise the importance of interactions for capabilities building, they differ in their assumptions concerning the portability of knowledge and both lack sufficiently detailed studies to understand precisely how interactions support capabilities building in firms and other organisations which are co-located in regions or in nations.

On the other hand, the approach of firm, organisation and strategy, the resource based view, explains how the mobilisation of resources within firms (Penrose 1995) and, more generally organisations, are essential for growth and improved profitability of the firm. Recognising that the value of specific resources evolves over time, the strategic management approach introduces 'dynamic capabilities' as being created by firms in order to succeed when faced with rapid economic and technological change (Teece and Pisano 1994; Teece, Pisano et al. 1997; Dosi, Nelson et al. 2000; Winter 2003). Additionally, in order to understand how dynamic capabilities evolve in firms, this literature proposes that there are micro processes within firms, i.e. organisational routines, which are some of the building blocks of capabilities (Nelson and Winter 1982; Teece, Pisano et al. 1997; Dosi, Nelson et al. 2000; Zollo and Winter 2002; Helfat, Finkelstein et al. 2007); which change over time because of the organisational learning processes carried out by individuals within firms (Teece and Pisano 1994; Teece, Pisano et al. 1997; Zollo and Winter 2002).

Both strands of the literature of evolutionary economics agree that the creation and accumulation of capabilities in firms are based on organisational learning processes that take place inside the firms and organisations (Teece and Pisano 1994; Teece, Pisano et al. 1997; Zollo and Winter 2002) and between firms and other organisations, (i.e. learning by interacting) or institutional learning processes (Lundvall 1988; Lundvall 1992; Lundvall 2005). However, the connections of those contexts still remain in the research agenda, as addressed before (Metcalfe 1994).

The literature about capabilities development is abundant, especially with respect to the study of the nature and consequences of dynamic capabilities of firms (e.g., Dosi, Nelson et al. 2000; Helfat, Finkelstein et al. 2007). On the other hand, the regional innovation systems approach acknowledges and studies spatial linkages, connectedness, interdependency, and/or networks of regional actors, which support innovative capability in specific clusters of firms or industries in specific regions (Cooke, Heidenreich et al. 2004; Asheim and Coenen 2005). Nonetheless, there are theoretical and analytical gaps in our understanding of how spatial interrelationships of actors in a system/region affect each others' organisational routines (as distinct from individual skills and routines) and capabilities, which are related with complementarities (Levinthal 2000), collective action (Nelson and Winter 1982) and coevolution of consumers and producers capabilities (von Tunzelman and Wang 2003; von Tunzelmann 2009a).

This research investigates how firms' capabilities evolve in a region because they are also assisted by other organisations. The accumulation of these capabilities is translated into improvements in the capabilities of the region, which eventually support a region's economic performance. The aim of this research is to theoretically and empirically improve our understanding of how capabilities building resulting from improved integration at micro-meso levels (and possible meso-macro levels) affected regional economic performance. In other words, the claim is that the current literature does not offer a clear explanation of how micro processes in firms (e.g., organisational and operational routines) change through the interactions of individuals within firms (Zollo and Winter 2002; Winter 2003; Winter 2003a) as the results of interactions with other organisations, and thus lead to regional capabilities (von Tunzelmann 2009a). In addition, there are some micro-meso implications for intra-firm (Zollo and Winter 2002; Winter 2003; Winter 2003a) and inter-firm development routines (Zollo, Reuer et al. 2002; Zollo and Singh 2004; Helfat, Finkelstein et al. 2007). This research elaborates on Levinthal's statement on how 'Routines, or other forms of linked behaviour, are powerful devices to enhance capabilities in a setting in which there are important complementarities in the behaviour of the various actors...in a complex world' (2000, p 363-364).

To fill these gaps in evolutionary economics, it is useful to employ a regional capabilities concept as a way of connecting the evolution of capabilities within firms with the expression of these capabilities at more aggregated levels; regions, systems, industries and (ultimately) countries[1] (Cooke 2005; von Tunzelmann 2009a). A concern with aggregation is particularly important in those industries in which most of the firms may be small or where capabilities are embedded in larger structures such as supply

[1] Countries may be seen as an aggregation of regions.

chains or filières. Regional capabilities are also relevant for understanding long-term economic growth especially in developing contexts (Cimoli, Dosi et al. 2009).

The regional capabilities concept is based upon the premise that changes in capabilities are not only the result of interactions among individuals within firms and organisations (as in the dynamic capabilities approach stresses) but also involve the interactions between individuals within organisations with individuals from other organisations (von Tunzelmann 2009a). Within a region, firms evolve their capabilities because capable individuals are able to integrate knowledge and technologies that come from internal and external sources (Cooke 2005).

A principal reason for using the regional capabilities approach is that, in a development context, it is often the case that what is desired is the replacement of a set of more or less traditional routines with routines that are fundamentally new, a revolutionary set of changes (von Tunzelmann 2009a). While such changes can be identified as having occurred in development history, e.g. the transformation from natural to artificial fertiliser in agriculture or from animal power to mechanisation, the processes by which large scale transition or transformation occurs are still not well understood. What is apparent is that such changes require fundamental transformations in routines, and that to implement these changes in routines, capabilities are required, capabilities which, themselves, are subject to evolution, i.e. improved and/or new capabilities. The fact that these capabilities come to exist across many individual units of production and may be embedded in larger structures such as supply chains suggests the need for a focus on regional level processes that span many different units of production. In this case, the diffusion of knowledge involves coordinated actions among different actors and these processes of coordination cannot be reasonably addressed by diffusion theory, which focuses on individual adopter behaviour to create local capability (Ernst and Kim 2002). Because of a lack of understanding on how the processes of capabilities evolution and accumulation work, policy recommendations for addressing capabilities development are somewhat questionable (Doloreux and Parto 2005).

Some researchers in capabilities development in developing countries have paid particular attention to the manufacturing of large successful firms as movers or drivers of change. For instance, the role of PETROBRAS in Brazil (Dantas 2006), USIMINAS and CSN in Brazil (de Figuereido 1999), UNILEVER in Brazil (de Campos 2006), and VITRO in Mexico (Dutrénit Bielous 1998). In the same developing contexts, research on changes in capabilities in traditional sectors (such as agribusinesses) is underdeveloped and almost no attention has been paid to them.

It has been argued that in traditional sectors, there are multiple innovators, geographically dispersed with no specific knowledge spatial boundaries (Breschi and Malerba 1997). They have technological regimes with multiple sources of knowledge and learning processes (Malerba 2005) with a mix of low-tech and high-tech that open opportunities for those sectors, in regions and countries to improve their capabilities and to enter into the international competition (von Tunzelmann and Acha 2005; von Tunzelmann 2009a). In this respect, research on the evolution of capabilities in the Mexican dairy sector[2] (hereafter MDS) is relevant in both theoretical and empirical terms.

In the context of intensive competition and globalisation (e.g. GATT,[3] now World Trade Organization, WTO and NAFTA[4]), which ended the long period of import substituting

[2] The MDS has been conceptualised as a global-regional system of milk and dairy production by Mexican scholars and analysts who have examined and assessed the potential impact of NAFTA on milk and dairy production (García Hernández, Martínez Borrego et al. 1998; Alvarez Macías 1999; Martínez Borrego, Alvarez Macías et al. 1999; del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000).

[3] The General Agreement on Tariffs and Trade (GATT) was originally created by the Bretton Woods Conference as part of a larger plan for economic recovery after World War II (WWII). The main purpose of GATT was to reduce the barriers to international trade through a reduction in tariff barriers and quantitative restrictions and subsidies on trade. Originally, GATT aimed to establish an international organisation, similar to the World Bank or the International Monetary Fund (IMF) to be known as the International Trade Organisation. However, agreement over its implementation failed, and GATT was periodically revised by multilateral negotiation. GATT's history falls into three phases: the first, from 1947 until the Torquay round, was largely concerned with which commodities would be covered by the agreement and with the freezing of existing tariff levels. The second phase which ended with the Tokyo round, was from 1959 to 1979 and focused on reducing tariffs. The third phase, which consisted of the Uruguay Round was from 1986 to 1994, and extended the agreement to the areas of intellectual property rights (IPR), services, capital and agriculture. This round saw the establishment of the WTO in January 1995, see WTO website: http://www.wto.org/english/thewto_e/whatis_e/tif_e/fact4_e.htm (April 12, 2007).

[4] NAFTA is the North American Free Trade Agreement, and is the largest North-South free trade agreement. From the earliest negotiations, agriculture was (and still is), a controversial subject within NAFTA, as it has been in almost all free trade agreements signed within the WTO framework. Agriculture is the only section that was not negotiated trilaterally; instead, three separate agreements were signed between each pair of parties. The Canada and US agreement contains significant restrictions and tariff quotas on sugar, dairy, and poultry; the Mexico and US agreement allows for wider liberalization within a framework of phase-out periods. The effect of the Mexico and US agreement has been a matter for dispute. In the case of milk and dairy production, NAFTA was and still is an important source of disequilibrating change which has provoked actions and generated tensions within the dairy systems of

industrialisation regime (ISI regime); Mexico, along with other developing countries, faces ever greater difficulties in competing with and catching up to the economic growth of richer countries. However, globalisation also offers conditions lowering the barrier for trade and inflows of technologies and creates new opportunities for economic expansion as long as a country is able to speed up the creation and accumulation of capabilities.

Research on the evolution of capabilities in the MDS has aimed at finding paths to economic sustainability which is important because the MDS has provided a way to mitigate some of the social problems related to malnutrition[5] (Aragón Mladosich and Gómez Ibañez 2004) and poverty, and has helped to reduce peasant migration to urban regions (del Valle Rivera 2000; Torres Torres 2003). It has also provided rural jobs[6] although its contribution to GDP is still modest[7] (Hernández Laos and del Valle Rivera 2000; SAGARPA-FAO 2006).

However, research on the evolution of capabilities in the MDS is complicated by the fact that the MDS is an agribusiness[8] sector involving both agricultural (or primary) economic activities and industrial activities. Thus transformation of the MDS requires multiple areas of knowledge and technologies that have to be analysed (e.g. animal husbandry, feedstock production, dairy production, etc.). This complexity presents many challenges for developing policy recommendations that aim to improve the performance of the sector. Multiple activities and interactions that involve numerous different actors must be carried out together in a coordinated way to update knowledge and technologies and integrate value chains. As a result, high quality fresh milk and dairy products with higher value added are expected than with the sector's traditional approaches.

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each of the signatories. These tensions have varied depending on the actors' capabilities to overcome the threats of increasing dairy product imports.

[5] One of the best ways to reduce malnutrition in poor countries is to feed children with milk. FAO website: http://www.fao.org/docrep/003/AA040E/AA040E00.HTM#TOC (August 20, 2004).

[6] Total rural areas account for approximately 23% of the economic population and 61% of the poorest people in Mexico (SAGARPA-FAO 2006). Job creation in the MDS was estimated at 1.5 million (ASERCA Editorial 1996, p 1).

[7] The share of the sector in GDP was estimated at 1.3% in 1996 (ASERCA Editorial 1996, p 1).

[8] According to Davis and Goldberg (1957, p 2) agribusiness is defined by 'the sum total of all operations involved in the manufacture and distribution of farm supplies; production operations on the farm; and the storage, processing and distribution of farm commodities and items made from them' (in Biere 1988).

Actors' capabilities in dairy farming differ significantly from dairy production. The reason is that the capabilities of dairy farmers are associated with highly heterogeneous firms of different sizes, using different technological systems of milk production, associated with climatic and socio economic features of regions. The output of these producers ranges greatly depending upon their capabilities for making profits combining different technological and organisational processes.

The MDS includes high quality standardised milk produced by a small number of large and medium-sized farmers using specialised and semi specialised milk production technologies who are concentrated in arid and semiarid zones with some in the temperate regions (around 10% of a population of 60,000). It also includes the less standardised product produced by the remaining small and family farmers using non-specialised milk production systems localised mainly in temperate and tropical regions. In addition, the capabilities of dairy processors also differ. A small number of medium and large-sized dairy firms processes most of the raw fresh chilled milk, with highly standardised processes similar to industrial or mass production (e.g. car production, textiles, electronic production, etc.), which require standard high quality raw fresh chilled milk. The MDS also includes a large number of artisan cheese producers, which process still a significant amount of milk to produce unpasteurised cheese and other regional dairy products. Then, the development of the MDS depends on the coevolution of the capabilities of these heterogeneous groups of farmers and dairy processors in their regions since most of the integration of their value chains is regional.

An additional problem in the study of the evolution of capabilities of the MDS is that the agricultural sector, i.e. milk production, as in most countries, is subject to strong government intervention because of its implications for food supply, international trade regulation, rural development and migration (García Hernández, del Valle Rivera et al. 1997; Rodríguez Gómez and Chombo Morales 1998; Martínez Borrego, Alvarez Macías et al. 1999). Therefore, the supporting organisations and the interactions of these organisations with farmers for innovation are complex making it difficult to analyse or develop policy recommendations aiming at creating and accumulating capabilities, or achieving economic sustainability, which is also a concern in this research.

To pursue further the introduction to this research, the following seven sections of this chapter aim: the first explains the motivation for this research; the second formulates the research questions; the third explains the positioning of the thesis and its contributions; the fourth introduces the research method; the fifth provides the main findings of this research; the sixth presents the structure of succeeding chapters; and the final section summarises the chapter.

1.1 Research motivation

A theory of economic growth that is both plausible and relevant to developing countries is that market competition processes do not work only to favour stronger firms or eliminate weaker ones. Groups of firms are influenced by specific factors; that is, stronger firms are limited in their capabilities and capacities for growth and weaker firms are able to co-exist at lower levels of productivity and higher prices or lower qualities of output. Thus, the accumulation of capabilities by leading and lagging firms is relevant to the performance of sectors over time as well as to the fate of individual firms. For example, weaker firms may become stronger if they manage to build capabilities and persist in the production system. However, weaker firms may be eliminated by the growth of stronger firms. Furthermore, the entire sector may be displaced by foreign competition if it is possible for foreign producers to overcome local barriers to trade and to offer products at lower prices than domestic producers. This latter situation, although plausible, has not yet occurred in the milk and dairy production sector of Mexico following NAFTA.

Despite the threat of displacement of domestic Mexican dairy farmers and firms under NAFTA, and the persistent heterogeneity of Mexican milk and dairy production in dairy regions, the MDS has grown faster (3.04% average annual growth for milk production) than the average annual growth of the GDP (2.67%)[9] in the period immediately after NAFTA (1994 to 2004). One of the motivations for this thesis is to understand how this happened.

[9] Author's estimates using data from INEGI, Sistema de Cuentas Nacionales (http://www.inegi.gob.mx/inegi/default.aspx) (March 30, 2006).

The MDS is comprised by approximately twenty dairy regions with heterogeneous milk production systems, with different climatic and socio economic conditions (Alvarez Macías and Montaño Becerril 1997; Peralta Arías and Lastra Marín 1999). However, as in most developed countries, Mexican dairy regions are increasingly introducing technologies and organisational processes that have replaced traditional processes and technologies for milk and dairy production in a so-called modernisation process.[10] Thus, some dairy regions have experienced a relentless convergence to world standard production processes for milk and dairy production (del Valle Rivera 2000). However, for reasons that will be elaborated later (see the cases of the Los Altos region, section 5.2; and the Tabasco region, sections 5.3 and 7.1), the evidence does not support the conclusion that this 'modernisation' is the sole path by which Mexican dairy regions will be sustainable in the long term.

My motivation for conducting this research comes from my experience in analysing the MDS prior to NAFTA. I was part of a consultant group that was engaged in analysing the competitiveness of milk production (among 42 other main agricultural products) for the Mexican negotiation team for NAFTA. We identified and analysed key issues related to the competitiveness of these agricultural products (e.g., costs of production and technological benchmarks). At that time, agricultural secretariat (SARH later on SAGARPA) was unclear about the technological disadvantages or advantages possessed by the Mexican agricultural sector because of the diversity of regional systems of production. This analysis provided the foundation for a negotiation process, in which it became clear that the agricultural sector was the most complicated to negotiate and to schedule for tariff free trade because of the greater disadvantages of Mexican agricultural production compared to that of the US in this sector[11] (Cervantes Escoto 2003). As a result, in the case of milk and dairy products, the scheduling of

[10] A modernisation process refers to the inclusion and upgrading technologies (e.g. specialised dairy cows, use of artificial insemination, intensive grazing, machinery and equipment for dairy and development of new operations) to produce a better quality of milk and to create improved and new dairy products. Besides an increase in the capacity, this has involved the improvement of technological and managerial practices in milk production and dairy processing. This modernisation process has also demanded changes from the dairy farmers and firms and restructuring of the value chain as well as the creation of new supporting organisations.

[11] It is important to note that the Canadian dairy industry did not join NAFTA because it was at a huge disadvantage compared to the US dairy industry. Specifically, Canada had high production costs due to overcapacity in its entire system, inadequate scales of production in individual units, and a complex industrial and political structure at the provincial level in the dairy industry (Bailey 1997; Bamford 1997; Tudor Price 1997; Côté 1999; Bailey 2002).

annual quotas and elimination of tariffs for non fat dry milk (NFDM) and dairy products extended over a period of 15 years (del Valle Rivera 2000).

During NAFTA negotiations, it was recognised that there were three important factors affecting the competitiveness of milk production in the MDS: a) its technological disadvantage in milk production because of the heterogeneity in the use of milk and dairy technologies, especially in the tropical regions (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000; Muñoz Rodríguez, García Muñiz et al. 2003); b) distortions in the international prices of NFDM and other dairy products (prices do not accurately reflect production costs), which resulted from the subsidised milk production in developed countries and unfair trade practices in NFDM (Marín López 1997; Marín López 1999); and c) Mexico's high dependence on foreign technologies and inputs for milk and dairy production, which makes the sector very vulnerable to changes in the economy (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000) (see Appendix I, subsection 2.2; and Chapter 2, subsection 2.2.1).

These factors and disadvantages seemed to persist until 2005 in some regions, although policies to reduce them were created and implemented from the beginning of trade liberalisation, which started with GATT. At the beginning of the Uruguay round of GATT, the Mexican government created an agricultural policy programme, i.e. PROCAMPO[12] (in 1986), a direct policy subsidy to support those farmers who were at a disadvantage in agricultural production. In 1995, PROCAMPO changed from giving direct subsidies to farmers to a development-oriented programme called Alianza para el Campo[13] covering five normative drivers for development: agriculture, livestock, rural, animal and plant health and technology transfer (del Valle Rivera 2000). However, these policies were represented as focusing mainly on mitigating the effects of NAFTA on small farmers in the short term and, in many cases, practice favoured the large farmers. As a result, by 2000, the average productivity of cows (i.e. litres per day per cow) of Mexico's national herd was still lower than that of the US and there was uneven

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[12] PROCAMPO (Programa de Apoyo para el Campo) was a direct policy subsidy to farmers to compensate for the high subsidies received by the foreign suppliers of NFDM (see Appendix I, section 1.1).

[13] Alianza para el Campo became the Alianza Contigo programme in 2003 to focus on agriculture rural development http://senasicaw.senasica.sagarpa.gob.mx/portal/html/senasica_principal/alianza_contigo/PAC_2003_REGLAS_OPERACION_DOF_250703.pdf (June 20, 2006).

growth across dairy regions (del Valle Rivera 2000; Cervantes Escoto and Alvarez Macías 2001; Cervantes Escoto 2003).

PROCAMPO and Alianza para el Campo policies have not shown to guarantee long-term improved sustainability of milk production for several reasons. One of the main deficiencies of these policies was the low level of investment in development of what we have defined above as regional capabilities. Development of such capabilities is one of the cornerstones of sustainable economic growth of the dairy regions and eventually of the MDS. The cross case analysis (Chapter 5) of the Mexican dairy regions provides evidence for this claim.

On the other hand, since Mexico joined GATT and signed NAFTA, dairy farmers, firms and consumers in Mexico have received some benefits. First, dairy firms have been able to access new markets; second, consumers have access to 'cheap dairy products';[14] and third, dairy farmers and firms have fewer barriers to importing production inputs and capital goods to upgrade their production systems. However, NAFTA also put pressure on dairy farmers and dairy firms to improve their ways of running a potentially vulnerable business, which has had the greatest impact on medium and small sized dairy farmers because of the recurrent economic crises in the agricultural sector[15] (Austin, Chu et al. 2004). With the arrival of NAFTA, many large farmers had already implemented new technologies and increased their productivity per cow by adopting specialised milk production system techniques (or an intensive model system), such as the Holstein model,[16] a technological advance with some similarities to the technologies

[14] This includes imports of NFDM of LICONSA. LICONSA is Leche Industralizada CONASUPO (Compañia Nacional de Subsistencias Popular), the oldest state trading firm, which administers social programmes aimed at reducing malnutrition among poor families through the provision or free or subsidised beans, tortillas and milk. LICONSA was set up in 1963 within CONASUPO to re-hydrate NFDM to produce 'pasteurised milk' for subsidised supplies for social programmes. LICONSA's role has influenced the MDS (see Appendix I, section 1.4, and the case of the Los Altos dairy region, section 5.2).

[15] Note that other factors contributed to hardship in the Mexican agriculture sector. In 1994, there was a Peso devaluation and in 1995, a banking crisis that dragged Mexico into an economic recession not seen since the 1930s, and was particularly damaging to the agriculture sector. Thousands of farmers lost access to credit and defaulted on their loans. Many abandoned farming and migrated to the US. Consequently, productive capacity was reduced in many rural communities. The extent of these problems is masked by remittances from workers who had migrated, often illegally, to the US. These remittances exceed the amount of capital flowing into Mexico from FDI. The rural crisis continued through the 1990s (Austin, Chu et al. 2004) and persists even in 2009. Furthermore, most money flows are basic household income for the majority of poor rural families although some is invested in creating agriculture capacity (see the case of the Los Altos dairy region, section 5.2).

[16] The Holstein model for milk production utilises specialised dairy cows, e.g. mainly Holsteins, a breed of European cows, but also Brown Swiss and Jersey cows, and complementary technologies to support

applied in the Green Revolution.[17] The Holstein model led to a restructuring of value chains (i.e. a better integration of dairy farmers with dairy processors) (Hernández Laos and del Valle Rivera 2000), which resulted in important improvements to the production of milk and dairy products in some regions (see the case of La Laguna and Los Altos dairy regions, section 5.1 and 5.2); but not in others (see the Tabasco dairy region, section 5.3).

The increasing use of new technology on dairy farms has focused on cost reduction and improving the quality of raw fresh milk, of which approximately 80% of milk output is commercialised at controlled chilling temperatures. The high quality of chilled milk and higher availability of volumes for processing led to the diversification of dairy production (Millman 1999; del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000). These changes are associated mainly with capabilities development and dairy infrastructure investments by dairy farmers and dairy processors, which were supported by other firms' suppliers and some private and public organisations.

To understand better the evolution of regional capabilities, this thesis undertakes a historical analysis of adjustments and changes in the Mexican dairy regions within the context of NAFTA. In the integration of the value chain, dairy farmers and firms perform economic activities within and outside their organisations when they interact with the suppliers of inputs and services. Suppliers of inputs and services (i.e. government organisations, financial organisations, universities, research organisations) also conduct supporting activities to dairy farmers and processors. Some of these interactive activities were strictly commercial, whereas others involved information and knowledge exchange, which might have provoked learning processes that led to capabilities building. However, the problem in this research is to identify how those

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the genetic capacity of these animals to produce milk (see subsection 2.4.1). This system of production came to be termed the White Revolution (analogy to the Green Revolution) in the US after WWII (Martínez Borrego and Salas Quintanal 2002). The Holstein model originated in the US where it is also referred to as the Wisconsin model, the EU model and the Israel model (Alvarez Macías 2005; Cervantes Escoto 2005; Madero Gámez 2005).

[17] During the 1960s and 1970s, the so-called Green Revolution swept Asia, Latin America, and parts of Africa. The Green Revolution technological package included high-yielding varieties of wheat, rice and maize, in combination with synthetic fertilisers, chemical pesticides, herbicides, fungicides and irrigation technologies. The primary objective of the Green Revolution was to modernise agricultural technology, thereby increasing agricultural productivity in countries experiencing rapid population growth and declining yields. The institutional framework for carrying out the Green Revolution in the South encompassed donor organisations and international agricultural research centres favouring specific technologies (Goldberger 2008).

capabilities changed within farms and dairy processors in the Mexican dairy regions affected by multiple organisations.

The integration of the value chains in dairy regions involves heterogeneous milk and dairy production systems and actors. Such integration is important to reduce transaction costs by milk farmers and dairy producers when they trade high quality chilled milk with standardised solids and low microbiological content. High integration improves the overall performance of the regions for two reasons: dairy farmers are not selling raw fresh milk at low prices and achieving poor levels of profit; and dairy processors are not being forced to overheat milk during pasteurisation or to use it for the production of lower value-added products, which is the case of artisan cheeses and milk-based confectionery producers. Thus, high integration of dairy farmers produces large volumes of high quality chilled milk for industrialisation and dairy firms are able to produce improved and new products and to expand into new markets, which are the main innovations[18] in milk and dairy production in the MDS.

Integrating dairy farmers and processors becomes more important when regions and countries face global markets and changes in international trade. However, competition in milk and dairy production is not driven primarily by dairy farmers' production costs or the costs of processing. It relies instead on the knowledge created by scientists and other experts, who have engaged in technological development and innovation in various areas of agriculture, food and dairy technologies (Alvarez Barrera 2004; Alvarez Macías 2005; Cervantes Escoto 2005; Quintanilla Alvarez 2006). Competition is also the result of demand of dairy products that are increasingly more sophisticated. Therefore, higher competition among national and international dairy processors, and closer relationships among suppliers of inputs and capital goods, development of sophisticated logistics systems for the supply of fresh milk and distribution of dairy products have transformed the sector into a 'type of knowledge based' industry. For these reasons, agricultural research institutes, government organisations, suppliers of technology and other development organisations have played important roles in the

[18] Innovation has a broad meaning in this research, i.e. introduction and use of knowledge, of new artefacts, new ideas or ways of doing things, etc. that are perhaps not new in other parts of the world. In this analysis, we generally refer to continuous improvements and/or incremental innovation to production and organisational processes, which lead to improve and increase milk production and dairy products, and to the production of new dairy products and/or markets.

development of capabilities to improve competitiveness in the MDS (Côté 1999; del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000).

In brief, the motivation of this research stems from the continuing challenges facing the MDS which were recognised from the beginning of internationalisation under GATT and amplified by NAFTA. These challenges have provoked fundamental changes and adaptations influenced by the institutional setting of the MDS which is an integral part of the analysis of capabilities development in this thesis. They have also involved fundamental changes in the operations and capabilities of all of the actors directly involved in milk and dairy production. These actors have collectively re-constructed the production and value chains to a greater or lesser extent and in these processes created different levels of regional capabilities. Diversity and uneven development are key themes that both motivate this research and provide the basis for research questions aimed at achieving a better understanding of the economic progress that has been reached and what would be achieved with appropriate regional development policies addressing the development of regional capabilities.

1.2 Research questions

The aim of this thesis is to investigate the extent to which the Mexican dairy regions have developed capabilities following NAFTA (1994-2004) to improve productivity[19] and competitiveness[20] with the goal of future regional economic sustainability.

Three factors are important in the analysis of economic sustainability in Mexican dairy regions:

a) the diversity of production systems related to agro ecological regions: arid and semi arid regions (north), temperate regions (centre) and tropical region (south-east);
b) the great diversity of farmers, with different technological and social needs, who nevertheless, have to be integrated into value chains in order to become

[19] Productivity in this research refers to efficiency in the use of goods for production, e.g. productivity per cow (litres per cow per day), profitability in farms and/or returns on investment in farms.
[20] Competitiveness is assessed as the rate of increase in milk production, improvement in the quality of milk, increase in the number of dairy products and development of new markets, all of which are affected by income growth in Mexico, as dairy products are income elastic ‘superior’ goods.

competitive when facing the new trade rules (Ekboir, Espinosa García et al. 2003); and

c) the importance of the MDS in agricultural activity for social development because rural jobs from this sector are estimated at 1.5 million (ASERCA Editorial 1996, p 1).

Therefore, a central question and a major challenge for Mexican farmers and dairy processors is how to engage in the globalisation process (Fischer 1998) in a way that will allow the dairy sector to be economically sustainable (Kaplinsky 2001) and competitive[21] (Krugman 1994). The main questions for this research are:

How have regional capabilities (intra and inter organisational capabilities) of dairy firms and their milk suppliers changed as a result of interactions with other regional actors (e.g. government organisations, research organisations, MNCs, universities, etc.) following NAFTA? Have these regional capabilities been responsible for improving the productivity and competitiveness of the dairy regions?

The concept of sector-specific regional capabilities (i.e. regional capabilities) is developed in this thesis to identify how some of the intra and inter organisational capabilities, which include specific technological and organisational capabilities, have co-evolved between dairy farmers and firms as well as other actors in specific regions. In particular, this thesis investigates how government organisations, research organisations, MNCs, universities, etc. have affected the coevolution of intra organisational capabilities of these firms and served to build up inter organisational capabilities, as dairy farmers and dairy processors increasingly integrated their value chains after NAFTA. These changes in regional capabilities have to be systematically compared in order to identify if they have improved the productivity and competitiveness of the regions and eventually, if these capabilities can support the future economic performance of the dairy regions in a highly price sensitive market. In order to do so, an analytical framework to analyse regional capabilities was developed. Acknowledging the local character of the learning processes for regional capabilities

[21] Defined as ‘the ability to produce goods and services that meet the test of international competition while citizens enjoy a standard of living that is both rising and sustainable’ by Laura D’ Andrea Tyson in her book *Who’s bashing whom* cited by Krugman 1994, p 31-32.

development, where improvements over time are affected by their social, economical and cultural contexts, we raise the following questions:

Have other factors impeded the development of regional capabilities? If so, how could future policies strengthen the capabilities building of the regions to support their economic sustainability?

The identification of these factors (blocking mechanisms and constraints) would provide also the bases for policy making and recommendations to support the development of regional capabilities for future economic sustainability of the dairy regions, a critical concern for government intervention. Therefore, policy intervention has to support capabilities building and/or to eliminate the factors that impede capabilities evolution. Since dairy regions have different structures and systems of milk and dairy production, a major challenge for policy makers is to develop policies that are appropriate for helping regional dairy farmers and dairy producers to speed up the development of regional capabilities and to change the institutions that affect their development.

This research focuses mainly on the interactions of regional dairy farmers and dairy processors in the system of milk and dairy production affected by other actors. The interactions among dairy firms, their distribution channels and consumers are beyond the scope of this research although some reference will be made to them where relevant.

1.3 Positioning of this research and contributions

Since most of the existing literature on capabilities development is focused mainly on firms' intra organisational processes in manufacturing and high tech sectors, and there is not a concept that integrates and explains how regional capabilities in agribusinesses evolve over time, this research develops the concept of sector-specific regional capabilities and an analytical framework to identify and analyse them. The concept is based on the propositions of Cooke (2005) and von Tunzelmann (2009a) that filling the gaps in the current literature on evolutionary economics, which requires studies that explain the development of capabilities in specific sectors and regions and which integrate the micro and meso levels. In particular, this research attempts to bridge the theoretical approaches of the firm, organisation and strategy and regional innovation systems, in order to understand the changes in resources, knowledge and learning mechanisms that trigger changes in routines within firms that create improved and/or new intra and inter organisational capabilities in regions in a specific sector; and how these changes in capabilities explain differences between regions' economic growth in a developing country.

Sector-specific regional capabilities are defined as the capacities of a region to change the micro processes of firms and organisations (coevolution of intra and inter technological and organisational routines) and their institutions to improve the production and commercialisation of competitive goods and services through interactive learning processes carried out by individuals within firms and organisations and among individuals from firms and other regional actors (e.g. research institutes, universities, technology transfer agents, suppliers of goods and services and government agencies). These interactive learning processes can also lead to changes in the capabilities of regional actors other than firms. Thus, sector-specific regional capabilities have the potential to affect the sustainability of economic growth of a specific sector in a region.

Sector-specific regional capabilities comprise firms and organisations capabilities, i.e. intra organisational capabilities and inter organisational capabilities, which are the results of the interactions of individuals within firms and/or organisations and among individuals of firms and other organisations (i.e. actors) (e.g. research institutes, suppliers or inputs, government organisations, financial organisations, universities, etc.) in regions, which are affected by their regional and national institutions. Thus, the concept integrates: a) micro level of firms, i.e. intra organisational capabilities, which comprise technological and organisational (managerial) capabilities, regarding knowledge content (e.g. R&D capabilities, marketing capabilities, processes capabilities, etc.); and b) meso level or regions, i.e. inter organisational capabilities (e.g. production capabilities, research capabilities, alliance-making capabilities, etc.).

The concept and an analytical framework to analyse them are built upon four main theoretical approaches: 1) firm level dynamic capabilities approach to understand the intra and inter organisational routines and processes that build up and change capabilities (Nelson and Winter 1982; Teece, Pisano et al. 1997; Dosi, Nelson et al.

2000; Zollo and Winter 2002); 2) regional innovation system approach (Maskell and Malmberg 1999; Gertler 2001; Gertler 2003; Asheim and Coenen 2005; Asheim and Gertler 2005; Asheim and Coenen 2006), including regional capabilities proposal (Cooke 2005; von Tunzelmann 2009a) to understand the production and diffusion of tacit and codified knowledge created in situated learning processes and their institutions that affect the evolution of capabilities; 3) sectoral innovation system approach to understand the appropriability and cumulativeness of knowledge bases and their sources in capabilities development (Malerba 2002; Malerba 2005); and 4) a function-based approach[22] (Bergek, Jacobsson et al. 2005; Jacobsson and Bergek 2006; Bergek, Jacobsson et al. 2008), another strand of the innovation systems approach, to carry out a systemic and systematic identification and analysis of the actors' interactions (collective activities, processes and mechanisms) that affect changes of routines and capabilities in dairy regions. Since there is no formalised way to compare regional capabilities, using this approach, it is possible to develop specific regional policies recommendations for capabilities development aiming at economic sustainability of the dairy regions.

By combining these approaches, this thesis articulates the logic of the collective activities, processes and mechanisms that contributed to the evolution of organisational routines into intra and inter organisational capabilities carried out by farmers and dairy processors affected by other organisations and the institutional set ups. These capabilities provide the foundation for a broader category called 'functions' in regional systems which are defined for the purposes of evaluation and assessment. By grouping capabilities that may arguably be related, it is more straightforward to assess the effectiveness (functionality) of the actors' interactions in building capabilities through the support of collective learning (e.g. technology transfer programmes, training programmes to develop farmers' capabilities) or the ineffectiveness (dysfunctionality) of a system's actors and the interactions between actors in the development and diffusion of knowledge for capabilities building. Comparison of the accumulation of capabilities in regions using the categories derived from an analysis of functions provides the elements required for policy making to address the future sustainability of

[22] This approach is also referred in the literature as a functional approach and functions in innovation systems. It proposes seven functions, which refer to the extent actors in systems are able to create and diffuse knowledge, to drive the research process, to support entrepreneurial experimentation, to facilitate market expansion, legitimation, to mobilise resources, and to create positive externalities (Jacobsson and Bergek 2006) (see section 3.5 in Chapter 3).

dairy regions. A ‘function’ oriented assessment or evaluation provides a guide for improving capabilities development at two levels, the micro level – capabilities within firms – and the meso level – changes in the institutions. It might also be possible that this normative functional analysis of sector-specific regional capabilities can be used in other agribusiness in developing countries.

The main argument of this research is that in regional innovation systems, firms carry out formal and/or informal interactions with other firms and organisations (e.g. suppliers of inputs, government organisations, research organisations, etc.); in which some of these interactions involve intra organisational learning processes. These learning processes influence the evolution of firms’ organisational routines into improved and new intra technological and organisational capabilities within firms/organisations, with which firms are able to improve and/or to develop new processes, products, services and markets. Some of these interactions also involve inter organisational learning and trigger some changes in the capabilities of other organisations and generate capabilities in the region that firms and organisations cannot develop by themselves, i.e. inter organisational capabilities in the regions. Thus, the intra and inter organisational capabilities co-evolve in regions and their simultaneous accumulation contributes to the economic sustainability of specific sectors in regions.

The contributions of this research are threefold:

a) Theoretically; the development of the concept of sector-specific regional capabilities and its analytical framework helps to identify and analyse, at a regional level, the mechanisms that support changes in routines and the coevolution of intra and inter organisational capabilities in regions supporting specific functions (the clustering of processes and mechanisms of capability building for the purposes of evaluation and assessment). This approach provides a micro foundation for explaining how systems work, by explaining the interactions of actors, which involve learning; and provides a dynamic and normative approach for explaining economic change. However, the concept and the analytical framework need to be further refined in order to make them more comprehensive and integrate them into innovation theory in developing contexts,

b) Empirically; the application of the analytical framework employed in this thesis has yielded findings at the sector-regional (meso) level of an important agribusiness, a sector that has not been studied before in a developing context. The systematic comparison of the structure of regions (actors, networks and institutions) shows that understanding situated learning due to the interactions of the actors regardless of the technological and structural disparities of the regions provides better explanations of the underlying processes that create capabilities and lead to different economic performance between regions compared with traditional growth theories and economic indicators, and

c) Policy making; by better understanding the micro foundation of capabilities and mechanisms that build capabilities, it is possible to improve policy making for regional policies by addressing firms' level (intra organisational) capabilities and systems level (inter organisational) capabilities and removing the constraints regions face in developing capabilities. By providing a mean for analysing and differentiating 'national policies' (top-down perspective) to align them with regional institutions and processes of local capabilities accumulation (bottom-up perspective), policies can be tailored to meet regional needs, ultimately creating more effective national performance. The emphasis on the development of differentiated regional policies rather than national policies is aimed at the pursuit of long-term economic sustainability and competitiveness of regions, which eventually might have an impact in the MDS. To do so, a normative function-base approach helps to highlight regional similarities and differences and to call attention to the relatedness and inter-dependence of the specific capabilities from which function categories are derived.

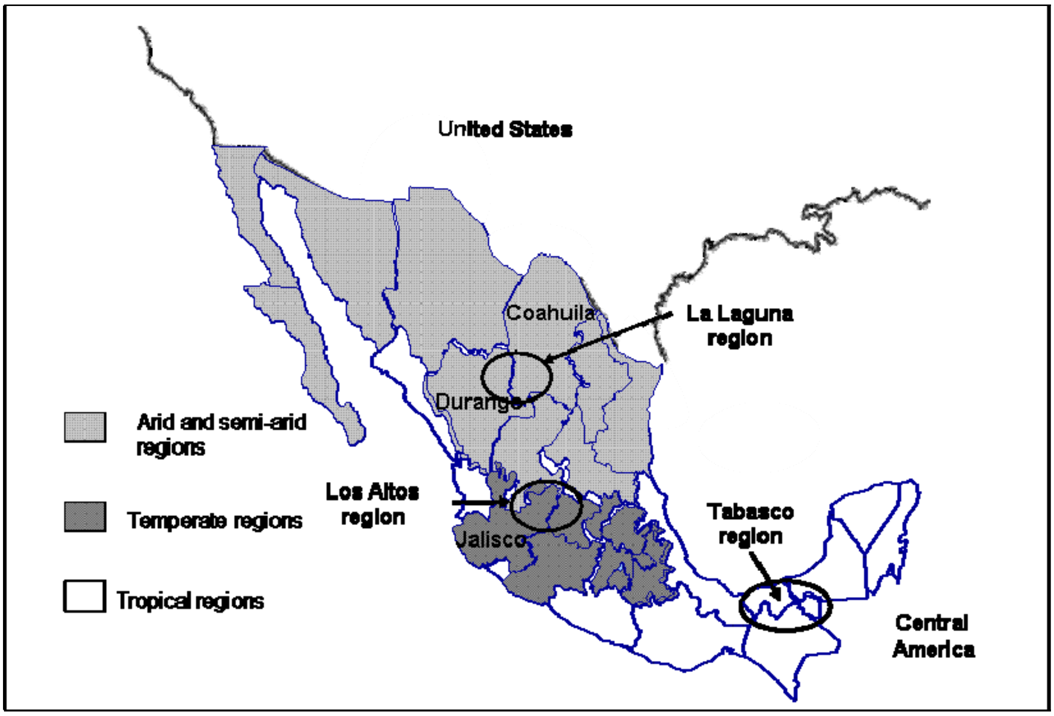
1.4 Research method

To answer the research questions we apply a qualitative cross-case methodology for the identification and analysis of regional capabilities. It presents explanatory cases of three 'representative' [23] and contrasting agro ecological and climatic dairy regions with a diversity of dairy farmers using different technological systems of milk production

[23] These three regions represent approximately 40% of milk production in 2004.

(Cervantes Escoto and Alvarez Macías 2001) and different socio economic backgrounds and needs (Ekboir, Espinosa García et al. 2003). These regions are shown in Figure 1.1:

a) the La Laguna region (hereafter La Laguna), typical of specialised milk production systems in arid and semi arid regions,
b) the Los Altos region (hereafter Los Altos), typical of semi-specialised and family run milk production systems in temperate regions, and
c) the Tabasco region (hereafter Tabasco), typical of dual-purpose milk production systems (most family run) in the centre of tropical regions.



Source: SAGARPA (2000).

Figure 1.1 Mexican dairy regions under research

The main information source for evidence about the development and evolution of regional capabilities is from analysis of 120 in-depth interviews in three dairy regions and at other locations carried out between May and September 2005. Secondary data sources including Mexican researchers' papers, books, and reports from government and private organisations provided complementary information for the evidence of regional capabilities development and the context of the MDS more generally.

1.5 Main findings

The core of the analysis is an examination of the interactions between dairy farmers and dairy processors in the increasing integration of regional value chains. These interactions led regional capabilities evolution and had implications for increasing the amount and improving the quality of raw fresh milk, which in turn led to increased production of pasteurised milk (i.e. long-life fluid milk in plastic containers and Tetra Pak™; and UHT milk in Tetra Brick™),[24] improvement and development of new dairy products and expansion of markets, from local to national and increasingly international.

Improvement in regional capabilities for milk production was the result of changes in the technological components of the routines and processes, which evolved into improved and new technological and organisational capabilities within farms (e.g. herd management capabilities and farming capabilities). They were developed through the interactions of farmers with dairy processors, suppliers of inputs for agriculture and dairy production and by government and development organisations, which affects the integration of the value chains of dairy farmers and dairy processors. Dairy processors also developed intra organisational capabilities, mainly by enhancing their management, R&D, marketing, branding and operations capabilities, based on their own resources and supported by national and foreign suppliers of inputs and technologies for dairy production. Coevolution of actors' interactions and learning mechanisms led to a set of inter organisational capabilities for milk and dairy production (e.g. research capabilities, technology transfer capabilities and alliance-making capabilities) in the regions.

The comparison of accumulated regional capabilities showed that La Laguna outperformed Los Altos and Tabasco in milk and dairy production. However, this thesis argues that the degree of regional capabilities development may not support the long-term economic sustainability of milk production. Specifically, the Tabasco and Los

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[24] UHT, Ultra High Temperature pasteurisation is a thermal process used to sterilise food before packaging or filling into sterile containers in a sterile atmosphere. Milk processed in this way, based on temperatures exceeding 135° C, with holding time between 2 to 5 seconds enabling a continuous flow operation. There are some variations in temperature and holding time. Highly contaminated milk requires higher temperatures or a longer holding time resulting in greater changes to the taste and quality of the milk. UHT milk is packed in special packages (Tetra Brick™) to have a shelf life for a minimum of six months without refrigeration. From Dairy Science and Technology, University of Guelph. http://www.foodsci.uoguelph.ca/dairyedu/uht.html (December 21, 2005).

Altos regions might engage in production of milk and dairy products only to the extent that they can effectively exploit specific advantages within their milk production systems. It also argues that some actors' interactions failed to support the development of small dairy farmers and firms' capabilities because of the inability of regional actors to improve conditions (i.e. market access, technological opportunities, favourable investment) to collectively develop such capabilities.

Based on the identification and analysis of capabilities that contributed to functions/dysfunctions in the regions, we conclude that regional capabilities developments are complex processes of learning carried out by interactions of several actors, which contributed to some functions in the regions. Large domestic dairy firms and MNCs (Nestlé) promoted the incorporation of technologies to increase the volume of high quality chilled milk, thus promoting the diversification of dairy production. They created learning processes that helped to improve routines and capabilities within farms in the regions. To a lesser extent, government organisations and research institutes (SAGARPA and INIFAP)[25] contributed to the *creation and diffusion of knowledge* specific to milk production using a specialised milk production system.

Government programmes and government funding organisations *mobilised resources* to build up parts of the infrastructure to facilitate the chilling of milk on the farms to preserve its quality for processing (e.g. Alianza para el Campo government support 'Tanques Rancheros' programme[26] in Los Altos). Nevertheless, there is neither the infrastructure nor the institutions required for national standardisation of milk and dairy production. Therefore, the system has failed to *legitimate* the quality of fresh chilled milk nationwide, a pattern of dysfunction with several consequences. Large volumes of high quality chilled milk are available in La Laguna and Los Altos. However, in Los Altos and Tabasco small dairy farmers and dairy firms are struggling to define the standards of quality of fresh milk and to achieve them; therefore, non-chilled milk trade persists. The situation is similar for the standardisation of the production and trade of

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[25] INIFAP is the National Research Institute for Forestry, Agriculture and Livestock (Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias) under SAGARPA.

[26] 'Tanques Rancheros' was a government programme in the late 1980s to establish a network of chilling tanks among groups of small and medium sized farms, where dairy farmers could chill their milk prior to it going to the processors. It was hoped that this would allow dairy farmers to be integrated into the production system and so improve the competitiveness of the region (Rodríguez Gómez 2000).

dairy products produced based on NFDM, caseinates,[27] milk preparations and milk whey. These 'cheap dairy products' have distorted the dairy market prices and confused consumers in terms of their perceptions of quality.

Another important dysfunction in the dairy regions is the lack of *direction of search*. Although productivity and competitiveness have been the drivers for dairy farmers and firms to innovate (e.g. genetic improvements in the herd to increase milk yields, and improving the logistics for milk collection and dairy distribution), there is no clear evidence of what regional actors want to achieve, especially in Los Altos and Tabasco (e.g. scale of milk production, technological specialisation in milk production, type of dairy products), nor how the actors involved want to achieve those goals (i.e. misalignment of the aim of actors). Increased uncertainty in the regulation of dairy product imports (i.e. dysfunction of *positive externalities*) and ultimately the intervention of LICONSA in the market for fresh milk are mainly affecting the small dairy farmers and distorting the prices of fresh milk and dairy products in the market.

Additionally, although La Laguna and Los Altos regions have experienced remarkable expansion that has led to the creation of well developed markets for high quality chilled milk and dairy products (*facilitating the formation of markets*), it is unlikely that these dairy regions can create the incentives to trigger new opportunities for complementary dairy business activities – for instance, production of heifers for herd replacements, semen production, milking machines appropriate for small herds, additives for dairy, etc. (*i.e. dysfunction in entrepreneurial experimentation*).

This research emphasises the lack of understanding for capabilities building in non-profit organisations which, although not a focus of this research, emerged as an important area for future research. This is especially important for agribusinesses where the intervention of multiple government and non-profit organisations is relevant for the development of regional capabilities of a moderately dynamic sector[28] facing changes in world trade.

[27] Caseinates are soluble salts of casein, a primary milk protein, which can be used as extenders (to increase the volume and weight of output) in cheese and other dairy products when mixed with milk and milk whey.
[28] The MDS is economically an important sector because it could potentially trigger or limit associated sectors' complementary activities, e.g. feedstock, grass seeds and semen production.

Finally, this thesis argues that domestic control of the MDS is superior in a social welfare[29] sense because it takes account of both consumer welfare and the costs of farmer dislocation that will be imposed by replacement of the current 'mixed' production systems with specialised systems in which northern and central semi specialised farms replace southern producers. Nevertheless, it is difficult to know what would replace dual-purpose milk production systems. It could be a system of specialisation in beef with residual regional artisan milk production (e.g.'Cotija' and 'de Poro' cheeses with Protected Designation of Origin, PDO), similar to the Buffalo mozzarella sector in Italy, numerous regions in France, and instances of farmhouse cheese production in the UK. While such a system would have displacement costs, its medium- or long-term social welfare implications might be less harmful if the specialisation of farms improved their productivity and the welfare of the farmers. A modern tropical dairy industry would be very desirable but might foreclose development of appropriate technologies with greater sustainability potential than the dominant package (the Holstein model) currently associated with modernisation that seems to prevail with potentially negative long-term consequences.

In exploring alternatives, NAFTA might not be the source of the problem (it might be too late to repudiate or modify the Agreement or too costly in other areas of the economy). In order to avoid dislocations for farmers caused by the increasing imports of dairy products, 'fixing' the regional dysfunctions that have worsened since NAFTA might provide a path towards long-term economic sustainability of dairy regions and might also ease or prevent social problems.

1.6 Thesis structure

The thesis comprises seven chapters connected as shown in Figure 1.2.

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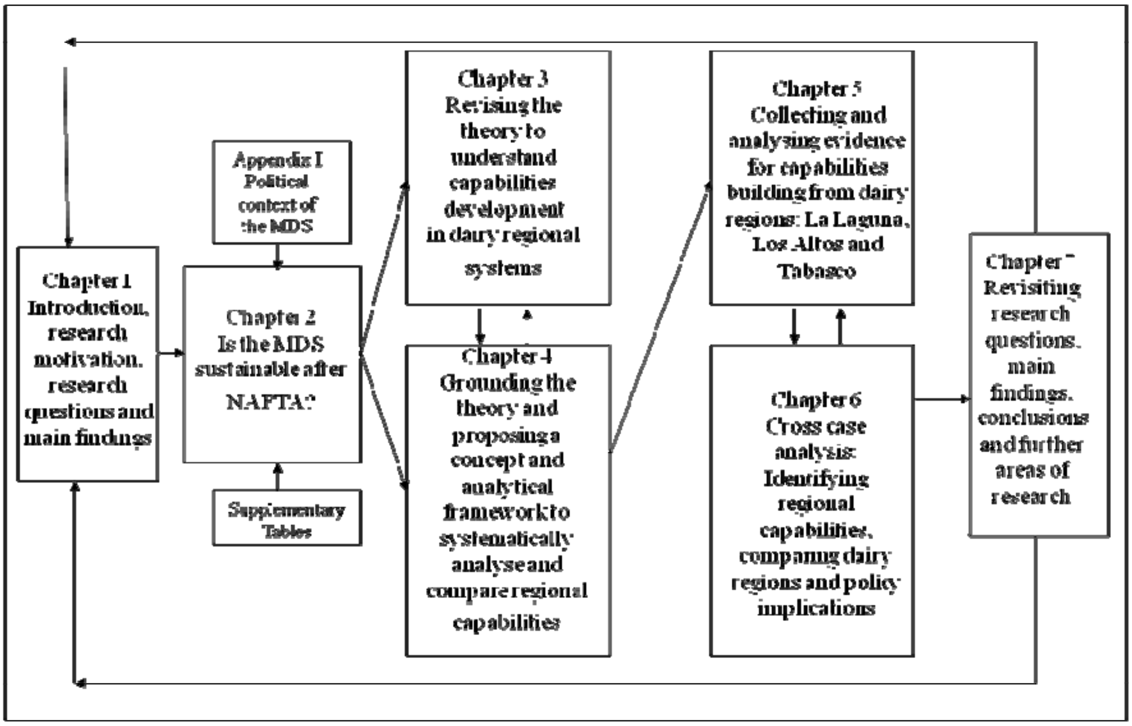
[29] 'citizens *enjoying* a standard of living that is both rising and sustainable' by Laura D' Andrea Tyson in her book *Who's bashing whom* cited by Krugman 1994, p 31-32.



Source: Author's elaboration

Figure 1.2 Thesis flow content

Chapter 2 introduces the research topic based on the historical evolution of milk and dairy production systems facing market globalisation after NAFTA and how these changes put pressure on the MDS to change. It shows how the different milk production systems have shaped the integration of the value chain and eventually the overall structure of the MDS (e.g. formation of networks of farmers to commercialise chilled milk, and formation of collective farms). It provides economic results for the MDS in the period of analysis for this research.

Chapter 3 reviews the literature to select the theoretical approaches to identify and analyse the development of capabilities in regions. It discusses in section 3.1 the empirical issues that have to be taken into account to select the theoretical approaches and selects the following approaches. Section 3.2 discusses regional innovation system (RIS) and regional capabilities approaches, and elaborates on why the interactions among different actors are important for the creation and exchange of tacit and codified knowledge, which is at the core of capabilities building in regions. It is followed by a discussion of the influence of the institutional contexts at the regional and national level for capabilities building. It also discusses the regional capabilities approach as a basis for the development of a concept and an analytical framework to guide this research.

Section 3.3 focuses on a sectoral innovation systems (SIS) approach for better understanding of the appropriability and cumulativeness of knowledge and technologies for capabilities development in a specific sector and complements RIS to integrate micro-meso level analysis.

Section 3.4 discusses capabilities building in firms' literature and is organised into five subsections. The first introduces a discussion of how the dynamic capabilities concept helps our understanding of the capabilities building process in firms and organisations. The second subsection discusses organisational routines as the building blocks of capabilities. The third explains the importance of distinguishing between technological and organisational capabilities in the use of specific technologies and to improve policy making. The next subsection explains how routines build firms' organisational capabilities based on collective learning processes; and the fifth explains how other organisations (e.g. government organisations, universities, research centres and suppliers) support the capabilities evolution within firms and their systems/regions.

Section 3.5 discusses the function-based approach literature that is employed to systematically identify, compare and analyse the development of capabilities in regional dairy systems. It explains how functions help to analyse the role of the actors involved in the socio-economic activities, processes and mechanisms, which play a major role in the development and change of capabilities, contributing to the functional pattern of the system and providing a framework to assess the evolution of capabilities and economic performance. Finally, section 3.6 summarises the chapter.

Chapter 4 grounds the theoretical approaches reviewed in Chapter 3 and develops the concept of sector-specific regional capabilities and an analytical framework to systematically analyse and compare the evolution of capabilities in three dairy regions to draw lessons for policy making. It has six sections. Section 4.1 links the research motivation to the main bodies of the literature to develop the concept and its analytical framework. Section 4.2 develops and explains the concept and its analytical framework and what the levels of observation would be for integrating the micro and meso levels to identify and analyse regional capabilities in dairy regions. Section 4.3 explains the multiple-case research method and its strategy for generating evidence on the development of capabilities in the dairy regions in Mexico. It explains why the three regions (i.e. La Laguna, Los Altos and Tabasco) were chosen as representative of different contexts that affect the development of capabilities. Section 4.4 expands on how theoretical concepts were used to operationalise an analytical framework to systematically analyse and compare by using a cross case analysis; the achievements, the capabilities building processes and the functions/dysfunctions that have contributed to the economic outcomes in the dairy regions. Section 4.5 explains the scope of the research and constraints for collecting evidence on capabilities building and section 4.6 summarises the chapter.

Chapter 5 provides empirical evidence on the development of regional capabilities in three dairy regions. Section 5.1 analyses the evidence from La Laguna, which is the most successful intensive user of dairy technologies in Mexico, and is similar to other arid dairy regions in the world (e.g. Israel and California). Section 5.2 examines the evidence from Los Altos, which is increasingly using technologies for milk and dairy processing similar to those used in La Laguna. Section 5.3 examines the evidence from the dairy system of Tabasco, which mostly uses dual-purpose systems for milk production. This region has increasingly incorporated technological components of the intensive model of milk production and has improved the integration of dairy farmers. Nevertheless, its pattern of development differs from the other two regions because of its socio economic and cultural environment.

Each of the three cases emphasises the structure of the regional dairy system and assesses the role of the actors that have promoted or impeded the development of regional capabilities. It identifies the main constraints in the regions, which, together with missing or underdeveloped capabilities, appear to have affected the functions/dysfunctions of the regions, which contributed to the economic development of milk and dairy production. The cases are summarised in section 5.4, which also introduces the cross-case analysis in the following Chapter 6.

Chapter 6 presents a comparative analysis of the dairy regions in terms of the contextual institutions and networks that have influenced the actors' activities to create different clusters of regional capabilities and economic outcomes in the dairy regions due to the functions/dysfunctions in the actors' interactions. It concludes with a set of policy recommendations for further sustainability of the Mexican dairy regions analysed in this research

Chapter 7 revisits the research questions in the light of the evidence from the three dairy regions. It discusses theoretical implications and contributions, limitations of this research and provides conclusions based on the findings. It suggests some areas for future research aimed at a better understanding of the evolution of regional capabilities as complex systems that would make the innovation system approach more robust. It also addresses the need to understand capabilities development in non-profit organisations, the possibility to apply the framework to study larger regions/nations and the need to study capabilities with multidisciplinary focus.

Supplementary data, identified in the main text, are also provided immediately before the references in supplementary tables and a short case, and an Appendix I. The Appendix is meant to be a primer for readers without a detailed understanding of the history of Mexican institutions. It explains the political context in which the MDS is embedded. It identifies supporting actors in the MDS and discusses the role of government organisations, which have influenced the development of the infrastructure through agricultural policy programmes and instruments. It also explains the influence of MNCs (Nestlé and the suppliers of agricultural and dairy inputs) on integration of the value chain leading the modernisation of the MDS.

1.7 Summary

This chapter has presented an overview of the thesis. It main argument is based on an alternative explanation of economic development based on capabilities building processes in regions. It explains the author’s motivations for pursuing the research questions through prior research on the MDS and proposes the concept of sector-specific regional capabilities and an analytical framework, which articulates four main different theoretical approaches that help to explain the uneven development and accumulation of regional capabilities, contributing to functions/dysfunctions in dairy regions from an evolutionary economics perspective. It identifies the need for regional policies for the future economic sustainability of the Mexican dairy regions.

Chapter 2. Research topic: Is the Mexican dairy sector sustainable after NAFTA?

This chapter provides a historical description of the changes of the MDS, since the enactment of the NAFTA. The focus of this chapter is on identifying the main features of the structure of the MDS, examining the main economic actors (i.e. dairy farmers and dairy processors) and the technologies used by them in the different dairy regions and their relationship with factors such as climatic conditions and the organisation of the value chains. It also identifies and analyses the main support organisations and institutions that build the MDS and how they have supported milk and dairy production. This chapter provides the context of the MDS and the factors that influenced regional dairy systems.[30]

This chapter is organised into nine sections. Section 2.1 provides an overview of the international market for milk and dairy production and explains the implications for the MDS of entry to the global market. Section 2.2 is a brief historical description of milk and dairy production and the NAFTA treaty. It shows how NAFTA changed the expectations of dairy farmers and firms and other actors about how to pursue economic growth. Section 2.3 introduces the structure of the MDS, i.e. main actors and main interactions. Section 2.4 explains the diversity and complexity of the milk productions systems prevailing in the MDS and the implications in the modernisation processes, i.e. integration with dairy processors. Dairy processing structure implications of its modernisation are explained in section 2.5. Section 2.6 describes the influence of the retailing industry. The economic results of the MDS after NAFTA are discussed in section 2.7. Some distinctive features of the Mexican and the US dairy industries are presented in section 2.8 to emphasise the asymmetries of the two systems. Finally, section 2.9 summarises the main insights of the evolution of the MDS following NAFTA.

[30] As already mentioned, further detail of the context of the MDS is provided in Appendix I.

2.1 Globalisation of the markets for milk and dairy products

Globalisation[31] of the milk and dairy products markets has had several implications for the development of dairy industries in various countries. First, changes in milk production and consumption patterns are related to changes in demographics, economics, political and other cultural processes, which are very difficult to assess (Wiley 2007). However, there is a general trend towards increased consumption of milk and other dairy products, also seen in the Mexican market.

Second, in 1994, milk production was highly concentrated in the EU, the US, India and the Russian Federation, with these areas accounting for approximately 73% of total production. However, by 2004, milk production in China, New Zealand and Brazil had increased faster than the world average and participation of the former main producers had decreased to around 50% (see Table 2.1). Thus, the world market includes more country players with a high potential for milk production.

Table 2.1 World milk production 1994-2004

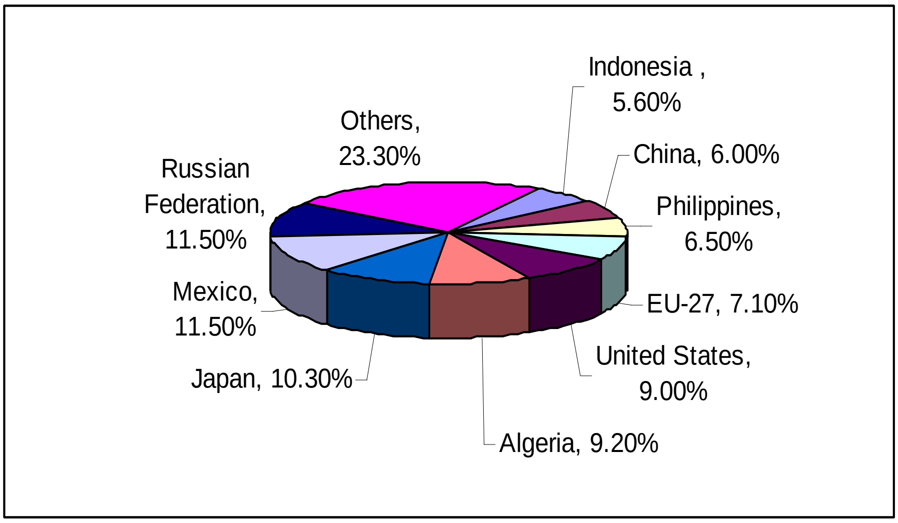
	1994		2004		CAGR[32] of volume of milk production 1994-2004
Countries	**Volume of milk production 000 tonnes**	**%**	**Volume of milk production 000 tonnes**	**%**	
China, Peoples Republic of	5288	1.38	22606	4.14	15.64
New Zealand	9719	2.53	15000	2.75	4.44
Brazil	16250	4.23	23317	4.27	3.68
Mexico	7547	1.97	9874	1.81	2.72
India	31000	8.08	37500	6.86	1.92
Argentina	7800	2.03	9250	1.69	1.72
United States	69701	18.16	77534	14.19	1.07
Australia	9719	2.53	10377	1.90	0.66
Canada	7547	1.97	7905	1.45	0.46
Japan	8388	2.19	8329	1.52	-0.07
EU-27	141477	36.87	133969	24.52	-0.54
Ukraine	18138	4.73	13787	2.52	-2.71
Russian Federation	42800	11.15	32000	5.86	-2.87
Others	8357	2.18	144857	26.52	33.01
World total	383731	100.00	546305	100.00	3.60

Source: Author's elaboration of data from FAOSTAT.[33]

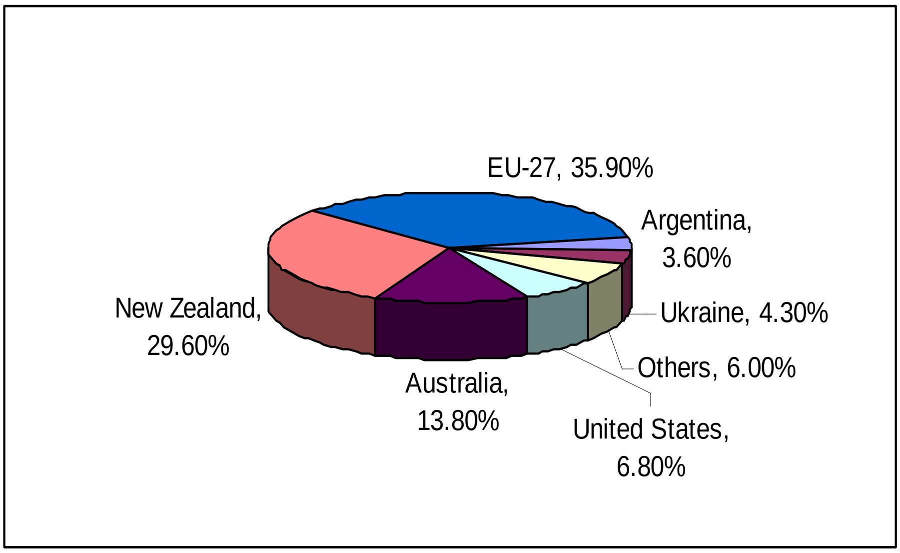
[31] Globalisation here refers to economic globalisation, which is the integration of national economies into the international economy through trade, foreign direct investment (FDI), capital flows, and the spread of technology (Bhagwati 2004).
[32] CAGR is Compound Annual Growth Rate.
[33] FAOSTAT website: http://www.fas.usda.gov/psdonline/csv/ukno0y55ukmbs4z0ulm4f5e5/output7.csv (June 20, 2008).

Third, global trade flows are unidirectional from traditional large-scale milk producers (i.e. EU, New Zealand, Australia and the US) to developing countries, accounting for more than 75% of international trade (see Figure 2.1) in butter, non-fat dried milk (NFDM),[34] and milk proteins (e.g. casein, caseinates, milk protein concentrates and whey), cheese, etc. (Richarts, Wohlfarth et al. 2004).

Importers



Exporters



Source: Author's elaboration of data from SAGARPA (2005).

Figure 2.1 Main world importers and exporters of dairy, 2004

Fourth, dairy is one of the most protected and regulated agro industries in the US and the EU (Tudor Price 1997). The reasons for this include the political influence of dairy farmers in the public policies that affect foreign trade (Akoorie and Scott-Kennel 1999;

[34] NFDM is a very basic and relatively inexpensive commodity, which can have a significant impact on dairy markets where prices are high, even if international shipping charges are taken into account.

Sankaran and Luxton 2003) and the fact that the dairy industry is highly regulated because its products are, in general, highly perishable and have the potential to carry food-borne diseases.[35] Thus, intensive and effective inspection programmes are required to provide a safe, reliable and standardised supply of fresh milk (Bailey 1997).

GATT obliged Mexico and other countries to change their protectionist policies and to adopt the neo liberal economic model. The argument for implementing GATT was that markets would create incentives for producers to invest without the intervention of governments. This neo liberal model was reinforced by the implementation of NAFTA, but with some unexpected consequences,[36] which raised doubts about neo liberal schemes (Stiglitz 2002; Stiglitz 2006). The neo liberal model seems also to work under specific conditions established by governments, which have been reluctant to liberalise trade in certain sectors, primarily because of the political influence of domestic actors in these sectors (e.g. US agriculture and Korean manufacturing sectors). Therefore, globalisation of the NFDM and other dairy products market is controversial, producing both benefits and damage according to groups with opposing interests. Some countries still subsidise milk production (i.e. EU and the US) which affects the economic interests of others (Dirven 2001; Stiglitz 2002; Tipping 2003). Some countries have been forced to restructure their production and distribution systems in order to maintain their positions in the world market (e.g. New Zealand and The Netherlands). Others have introduced improved technologies to increase the productivity of their dairy herds, and provide improvements in dairy processors, and conservation and distribution systems, enhanced by the application of information and telecommunication technologies (ICTs). However, these changes have been motivated mainly by increasing competition in the global dairy market (Bamford 1997; Tudor Price 1997; Akoorie and Scott-Kennel 1999; Côté 1999; Sankaran and Luxton 2003).

2.2 Historical evolution of the Mexican dairy sector

To understand the evolution of regional capabilities requires looking at the historical context of the MDS. Development of the MDS can be said to have occurred in three

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[35] A limited number of dairy products are less perishable. For instance, mature cheeses, NFDM, caseinates and powdered milk whey.

[36] See details on: The effects of NAFTA on U.S.-Mexican trade and GDP (http://www.cbo.gov/ftpdocs/42xx/doc4247/Report.pdf) (July 25, 2007).

stages: first from micro to regional production and distribution of milk during the *porfiriato regime* (1876-1911) (Goldfrank 1975); [37] second, the introduction of specialised milk production systems in the early 1950s; and third the evolution of the MDS after NAFTA.

Mexican milk production began with the Spaniards introducing dairy farming during the Conquest (in the mid 16th century). Livestock helped them to expand their territory and provided them with food, clothing, energy for lighting and traction. In 1560, there were around 100,000 cattle in Mexico, and this had increased to 10.5 million by 1620. Production and commercialisation of food was micro regional because of the absence of a communications and transportation infrastructure within and between regions. During the *porfiriato regime*, the construction of modern transport systems began along with inter-regional commercialisation of food (García Hernández, Martínez Borrego et al. 2000, p 157-158).

At the beginning of the 20th century, the country's head of cattle was estimated at 10.2 millions,[38] which suggests that numbers had changed little during the period 1620-1910. [39] Between the Mexican Revolution (1910-1917) and the end of WWII, production and commercialisation of milk was local and carried out by dairymen 'in bulk',[40] door-to-door, without any sanitary control. The introduction of agricultural technologies took off in Mexico after WWII, although they were in use in other parts of the world in the 1930s. In adopting imported agricultural technologies, Mexican milk

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[37] *Porfiriato* was a political regime led by Porfirio Díaz who ruled Mexico from 1876-1911. He led Mexico into the 'modernisation age' based on the *científicos* (a technocratic clique). This included the building of a modern rail network, the development of telegraph lines across the country, and important industries with large influxes of foreign capital invited by Díaz and welcomed, in the form of participation of select groups (i.e. the entrepreneurial bourgeois). This process led to the rise of important economic regions (e.g. textiles in central Mexico and Cananea copper mining in northwestern Mexico) with a large urban proletariat as well as a large group of rural discontents and landholders. His authoritarian methods and the daily brutality of the police and *rurales* (mounted police who preyed on rural communities), and the severe repression of illegal acts (such as looting) by indigenous rebellions, in order to keep the peace and ensure the continuing flow of FDI and growth of the economy continued until his rule ended with the start of the Mexican Revolution in 1910 (Goldfrank 1975).

[38] This was distributed 30.5% in the North, 10.4% in the South Pacific, 9.9% in the Gulf of Mexico region, 33.4% in the Centre and 15.8% in the North Pacific (Yearly Mexican Statistics, Anuario Estadístico de la República Mexicana, México 1902, cited by García Hernández, Martínez Borrego et al. 2000, p 157-158).

[39] This suggests that there were no important changes either in the land tenure regime or in the technology to increase the number of animals because of the micro regional systems prevailing in that period. It could also be that the conversion of grazing land to cultivated land affected the evolution of the cattle herds.

[40] 'In bulk' refers to the distribution of non-chilled milk using traditional churns.

production became linked to a global agricultural system, whose main players were the US, Canada, Europe, Australia and New Zealand. These linkages were established based on different patterns of development (García Hernández, Martínez Borrego et al. 2000, p 157-158). It could be said that early adoption of specialised cows known to produce good milk yields (i.e. the Holstein, and other European cows) in La Laguna in the 1950s marked the second stage in the modernisation of the dairy industry (see the case of La Laguna, section 5.1 in Chapter 5).

2.2.1 Mexican dairy sector and NAFTA

In the years before GATT (in the late 1970s), the Mexican government had developed an integrated policy for food production system called the Sistema Alimentario Mexicano or SAM (Mexican Food System) (Taylor 1990). SAM aimed at achieving self-sufficiency in basic food crops and protein sources (e.g. corn, milk, beef, hogs and poultry) to improve the nutritional levels of the poorest groups in the population (Barkin 1987).

SAM was part of the Import Substituting Industrialisation (ISI) regime that Mexico followed from the late 1930s through the early 1980s (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000). The goal of the ISI regime was to replace the large and growing array of imports with a modern, national industry that could supply domestically produced goods. Protection of industry development was planned through tariffs and quotas, as well as tax exemptions for strategic industries. The ISI regime was characterised by the coexistence of state-owned firms – national private firms, which produced consumer and intermediate goods, and MNCs which concentrated on producing more advanced processed goods (Bair 2000).

The ISI regime was undoubtedly successful in stimulating Mexico's economic growth. Its post-revolutionary experience (along with the hegemonic role of the quasi-state political party, the Partido Revolucionario Institucional, PRI) was at its strongest during this period, ensuring domestic firms had healthy profit margins in a closed market, and promoting a period of relative cooperation between labour and capital. However, this exceptional growth also contributed to a series of economic crises, which began in the late 1960s and were caused primarily by a negative balance of payments problem, which persisted for a long time. Although Mexico was initially able to finance the ISI regime through agricultural surpluses and later through petroleum exports, these sources were exhausted by the early 1980s and Mexico was plunged into its worst economic crisis with a major devaluation of the Peso (the Mexican currency) in 1982, which saw the end of the ISI regime (Bair 2000).

Mexico's accession to the GATT in 1986 was the first move towards greater openness to trade and foreign direct investment (FDI). The country's economic development strategy introduced the abolition of tariffs, the indexing of wages, and a new relationship between the state and organised labour. Mexico's adoption of a new development paradigm, and particularly its focus on export-oriented growth as the most central tenet of this strategy, was further solidified with the signing of the NAFTA in 1994 (Bair 2000).

The NAFTA involved an agreement to eliminate tariff and non-tariff barriers between Mexico and the US for powdered milk and dairy products over 15- and 10-year periods respectively, 1994 to 2008. After complicated negotiations over the agricultural tariff agreement, Mexico's tariffs on fluid milk and cheese imported from the US were set to decline to zero in 2003. US cheese imports now entered Mexico duty free while cheese imports from third country suppliers faced tariffs of around 20% (Dobson 2003). Mexico retained a quota on NFDM (below which there was no tariff) that would increase at 3% annually. Over-quota tariffs on NFDM began at 133% in 1994, and went to zero in 2008 (see Table S2.1).

The most important challenges for the MDS during the NAFTA negotiation were:

a) that Mexican dairy farmers were at a technological disadvantage in the production of milk especially in tropical regions (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000; Muñoz Rodríguez, García Muñiz et al. 2003);
b) that there was a distortion in the international prices of NFDM and dairy products (their prices did not accurately reflect the costs of production) because of subsidised milk production in developed countries and unfair trade practices in NFDM (and other grains that are used to produce milk) (Marín López 1997;

Marín López 1999; del Valle Rivera 2000), which have influenced negatively the social conditions in many rural areas (Romero Tellechea 2005); and

c) that the high dependence of Mexico on foreign technologies and inputs for milk and dairy production (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000) left the sector very vulnerable to changes in the economy for a sector making important contributions to public health (Aragón Mladosich and Gómez Ibañez 2004).

However, NAFTA facilitated better access to technologies and inputs for agriculture and milk production, which when incorporated into farm practice led to many advantages and benefits:

a) the increased production of high quality chilled milk, which is milk with low bacteria and somatic cell counts, was based on the application of good hygiene practices on farms and improved herd health; production of milk with a high fat and protein content as a result of improved animal nutrition; and the conservation of milk quality through efficient milking and chilling systems;

b) the extent of the integration of the dairy farmers and dairy processors based upon large networks of suppliers of chilled milk, to provide substantial amounts of high quality chilled milk to dairy processors from many dairy regions.

Thus Mexican dairy processors could follow the international trend in dairy production (i.e. production of long shelf-life pasteurised milk, yogurt and other functional dairy products), but adapted to consumers' tastes (Canedo Parra 2005; Díaz Bustamante 2005; Guerrero Jiménez 2005; Hernández Astorga 2005; López López 2005). The main difference in the Mexican dairy market compared with other markets is in the types of cheese. Mexican markets prefer soft cheese with a bland taste and hence no aging. These processes were dominated by large national dairy firms (e.g. Lala, Alpura and Sigma Alimentos) and MNCs (e.g. Nestlé and Danone), all of which are dependent on foreign inputs and technologies for the modernisation of their products, processes and markets (Casas Pérez 1997; del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000).

At the same time, the prevailing institutional arrangements in Mexico (i.e. the lack of institutional mechanisms to reduce corruption in the allocation of resources from PROCAMPO/Alianza para el Campo and a black market in dairy products), and recurrent economic crises impeded the enforcement of NAFTA rules regarding agreed quota systems and the payment of tariffs on NFDM when they exceeded quota (Alvarez Macías 2005). The increased imports of NFDM and milk preparations to produce 'cheap dairy products' benefited low income consumers, and was used politically to control inflation (Alvarez Macías 2005; Cevallos Urueta 2005). It also benefited dairy processors.[41] However, according to PROFECO[42] (PROFECO 2005) it misled consumers and damaged the interests of small dairy farmers, many of whom exited the market because they did not have the resources to improve their production to compete with subsidised milk and dairy products (Cervantes Escoto 2005; del Valle Rivera 2005; Rodríguez Gómez 2005).

In summary, the modernisation and economic performance of the value chain in the MDS depended on the degree of integration of high quality milk supplies in the dairy regions and the development of a varied supply of dairy products to satisfy a segmented national market (Euromonitor 2005) and, recently, to enter an international market, such is the case of a few large firms.

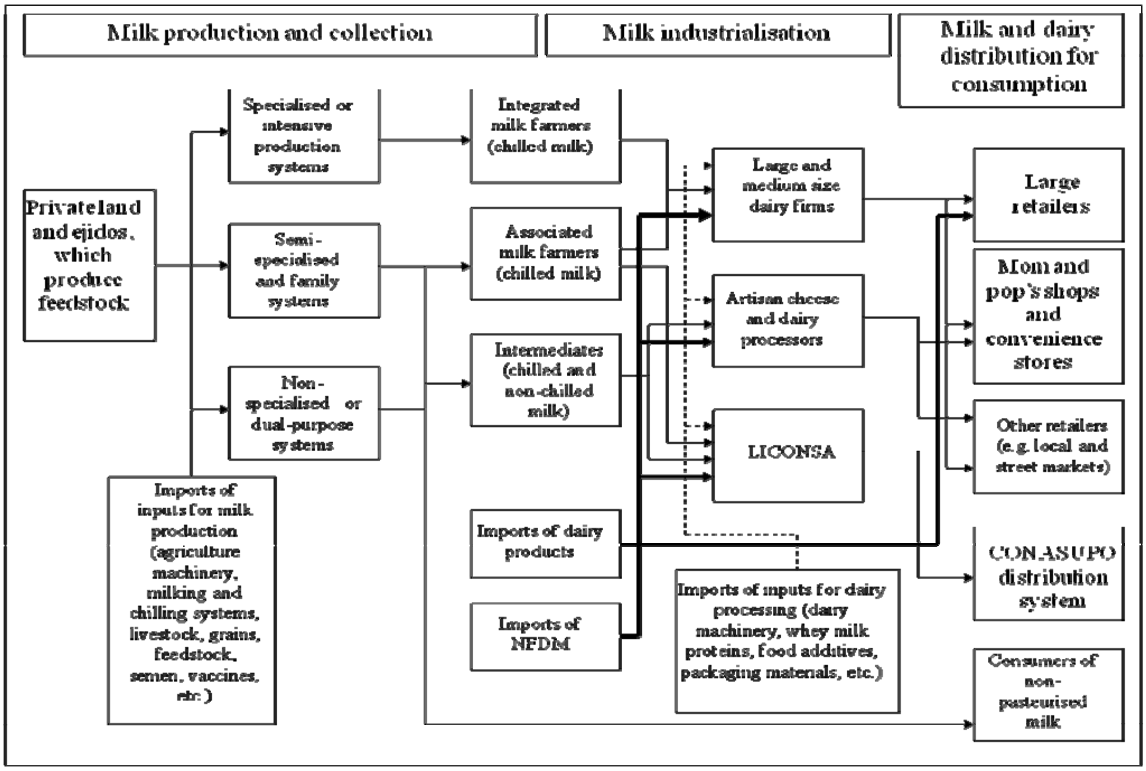
2.3 Structure of the Mexican dairy sector

In order to understand the coevolution of MDS actors' capabilities to overcome their disadvantages in an open market, it is helpful to understand the structure of the MDS value chain in terms of the three main interdependent subsystems and their actors (see Figure 2.2):

1) milk production systems, i.e. dairy farmers' activities (estimated 60,000 dairy farmers in 2004) (data from SEDESOL Prensa 2004), which fall into different groups depending on the economic and technological capacities of their milk production systems (i.e. specialised, semi-specialised, and dual-purpose systems);

[41] It is also possible that dairy processors could buy 'cheaper milk' produced from NFDM, which is rehydrated on farms and sold as raw fresh milk (interviewees who wanted to remain anonymous).
[42] PROFECO (Procuraduría Federal del Consumidor) is the Federal government agency in charge of law enforcement to defend consumers' rights.

2) dairy industrialisation, i.e. the dairy firms' activities to pasteurise and package fluid milk, and manufacture and distribute dairy products, which is dominated by a few large and medium sized firms, which co-exist with numerous small artisan producers (i.e. cremerías y queserías) and LICONSA (Hernández Laos and del Valle Rivera 2000); and
3) milk and dairy distribution and consumption, i.e. the networks of small and large retailers,[43] which supply milk and dairy products to consumers whose demand for milk and dairy products has increased over time.



Source: Adapted from del Valle Rivera (2000, p 235).

Figure 2.2 Structure of the Mexican dairy sector

The focus in this thesis is on the interactions between dairy farmers and dairy processors (the subsystems of milk production and processing) that are related to integrating the value chain. Therefore, following Malerba (2002; 2004) (using the definition of sectoral innovation systems, SIS), the MDS can be defined as a multi-dimensional, integrated and dynamic group of dairy farmers and dairy producers activities, whose processes of competition and cooperation (i.e. learning processes)

[43] These subsystem activities and interactions, as explained in section 1.2, are not included in the analysis.

have evolved, supported to a degree by other actors and institutional arrangements, to regulate the markets for milk and dairy products. These other actors are:

a) SAGARPA and its state offices (e.g. SAGARPA La Laguna, SEDAFOP in Tabasco and SEDAGRO in Jalisco) and the Federal programmes PROCAMPO and Alianza para el Campo related to milk production and the committee for the system of milk and dairy production (i.e. Comité para el Sistema Producto Bovino Leche, CSPBL)[44] (see Appendix I, section 1);
b) The Mexican system for agricultural research (Sistema Nacional de Investigación Agropecuaria, SNIA) (Ekboir, Espinosa García et al. 2003) comprised of: 1) SAGARPA and its agricultural universities, the Universidad Autónoma de Chapingo (UACh); the postgraduate agricultural college, CP or COLPOS (i.e. Colegio de Posgraduados), and the Universidad Autónoma Agrícola Antonio Narro (UAAAN); 2) INIFAP; 3) the faculties of agronomy and veterinary medicine of the state universities; 4) the agricultural colleges, Institutos Tecnológicos Agropecuarios, ITAs, within the Secretary of Education (Secretaria de Educación Pública, SEP); 5) the state Council for Science and Technology (Consejos Estatales de Ciencia y Tecnología) within CONACYT[45]; and 6) the patronage for agricultural research, Patronato de Apoyo a la Investigación Agropecuaria (COFUPRO) and its state organisations, i.e. Fundaciones Produce, with the participation of farmers to define the priorities of agricultural research led by INIFAP, getting resources from SEP, SAGARPA-CONACYT programmes and Alianza para el Campo for the technology transfer carried out by DEPAI[46] and GGAVATT[47] groups (Román Ponce, Bueno Díaz et al. 2001) (see further explanations in section 2.4.5 and Appendix I, section 1.2);

[44] CSPBL is a national committee set up under SAGARPA in the Coordinación General de Ganadería (Livestock General Coordination Office). It should coordinate all the activities of the MDS actors aimed at improving productivity and competitiveness in the economic units of the MDS. It has representation from most of the actors involved in agriculture and rural development in the country, e.g. government organisations, dairy cattlemen's associations, private organisations for the development of dairy cows, and dairy industry. CSPBL was set up in 2001 under the law for the sustainability of the rural development (i.e. Ley de Desarrollo Rural Sustentable) (see SAGARPA website http://www.sagarpa.gob.mx/Dgg/ley/Ldrs.pdf). The regulation was enacted in November 2005 (SAGARPA website http://www.sagarpa.gob.mx/Dgg/comite/reglamento_def.pdf) (May 11, 2007).
[45] CONACYT is the state Council for Science and Technology (Consejos Nacional de Ciencia y Tecnología).
[46] DEPAI (Desarrollo de Proyectos Agropecuarios Integrales, Development of Integrated Projects for Agriculture) is the largest integrated agriculture extension activity of SAGARPA.

c) LICONSA, its social programmes, its development activities and its fluid milk collection programme (Programa de Adquisición de Leche Nacional, PALN) (see details in Appendix I, section 1.4);

d) the financial organisations for development: FIRA, FIRCO and Financiera Rural (see further details in Appendix I, section 1.3);

e) the MNCs who play important roles: Nestlé drives the integration of the value chain in tropical and temperate regions; and the MNCs supply the inputs for agriculture, milk production and dairy processing (see details in Appendix I, section 2);

f) the livestock producers' associations (e.g. CNOG, UGR La Laguna, UGR Jalisco, and UGR Tabasco), and the professional and industrial organisations (e.g. ANGLAC and CANILEC) (see further details in Appendix I, section 3).

These groups of actors and their interactions[48] with dairy farmers and dairy processors constitute what we refer to as the Mexican Dairy System of Innovation (MDSI) (see Figure 2.3). For this research, the focus is on the dairy farmers and dairy firms' capabilities building processes, which use a specific knowledge base, technologies, institutions, networks,[49] inputs and demand that are the major drivers of the system's innovation processes.

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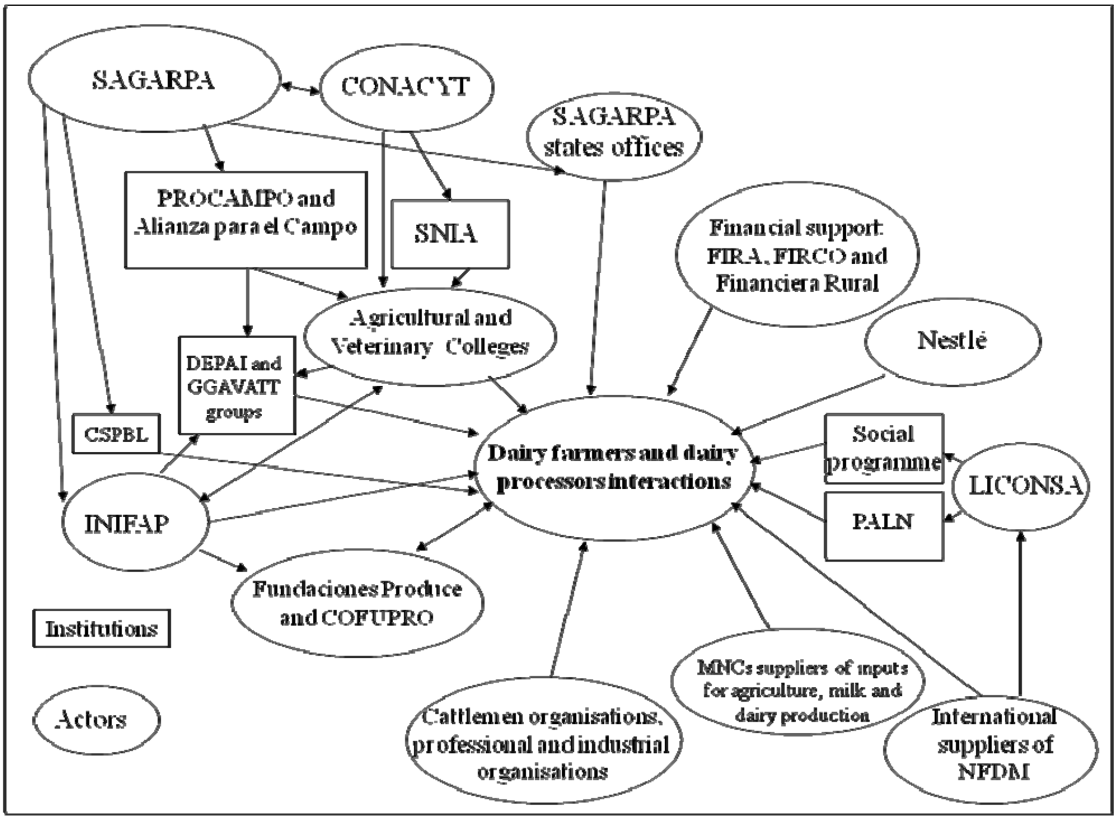
[47] GGAVATT (Grupos Ganaderos de Validación y Transferencia de Tecnología) is a method for validation and technology transfer from INIFAP to cattle farmers. It is part of INIFAP's national programme for technology validation and transfer (PRONAVATT, Programa Nacional de Validación y Transferencia de Tecnología) and is part of the national system for research and technology transfer for sustainable rural development (Sistema Nacional de Investigacion y Transferencia de Tecnologia para el Desarrollo Rural Sustentable, SNITT) (Alvarado Martínez 2005).

[48] Following Malerba (2002), these actors influence the following activities:

- regulation of prices for fresh milk and international trade (quotas and tariffs) in imports and exports of NFDM and dairy products;
- knowledge and learning processes that shape the production and innovation of dairy farmers and dairy firms; for example, the increasing introduction of technologies in milk production systems (specialised, semi-specialised and dual-purpose, and dairy product technologies) and their interdependences with supporting organisations, whose interdependence (vertically and horizontally) and complementarities define the boundaries of the system in the regions;
- mechanisms of technology transfer (i.e. DEPAI and GGAVATT groups) in milk productions; and alliances with foreign firms for dairy processing;
- competition and selection for firms to stay in business after GATT and NAFTA;
- institutions related to standardisation of dairy products (e.g. COFOCALEC).

[49] These networks and institutions span national boundaries, which provide further justification for the use of RIS and SIS as governing approaches, which are introduced in sections 3.2 and 3.3.



Source: Author's elaboration.

Figure 2.3 Mexican Dairy System of Innovation

The main changes among supporting actors and policies in the MDS, starting with GATT and consolidated by NAFTA, are summarised in Table 2.2 (see also Appendix I for a further explanation of the actors and their institutional arrangements in the political context of the MDS). Some of the changes show a clear lack of support to the sectors, such as the reduction in the Alianza para el Campo budget and the lack of resources for the technology transfer programme; and in other cases, policies that have produced contradictory results, e.g. the intervention of LICONSA and the liberalisation of milk prices.

Table 2.2 Political changes and impacts in the MDS since GATT and NAFTA

Political changes	Main impacts
Changes in the ISI regime	Dismantling of the protectionist agricultural policy, elimination of certain subsidies for agricultural production GATT (1986) and setting up of quota systems to import NFDM and dairy products with NAFTA (1994)
Changes in the agricultural policy	Emergence of PROCAMPO (1986), direct subsidies to farmers to mitigate GATT effects (and later NAFTA effects); this became Alianza para el Campo (1995), a development-oriented programme. Limited results that mainly favour the development of intensive milk production systems Important reduction of resources for Alianza para el Campo in the period from 1995 to 2004 (CAGR of -2.13%) (see Table A1 in Appendix I)
Changes in dairy policies	With the exception of intensive milk production systems, limited results from a programme to achieve self-sufficiency in milk production (i.e. Programa de Transición hacia la Autosuficiencia Lechera, PROTAL, 1989) and to increase the production of milk and to reduce the imports of NFDM and dairy products (i.e. Programa de Producción de Leche y de Sustitución de Importaciones, PLSI, 1996-2000)
Establishment of the CSPBL	It has not served better planning and agreement for the integration of the value chain of the MDS[50]
Emergence of agricultural development organisations	Emergence of new organisations, Fundaciones Produce (1995) and COFUPRO (1997), to influence R&D for agriculture and dairy production; and increasing support for knowledge creation and diffusion institutions (e.g. PIAL[51] projects in La Laguna region, and promotion of DEPAI and GGAVATT methods for technology transfer mainly in the temperate and tropical regions. GGAVAT became the 'official' technology transfer process in Veracruz. Nevertheless, it has important limitations (e.g. lack of updating technologies and development of capabilities for commercialisation), the most important being the lack of resources to implement it with numerous small farmers
Changes in the land tenure system	'Ejidatarios' were able to make decisions about the ownership of their land (1992) and its use. [52] Nevertheless, this change did not attract the private investment expected
Changes in the structure of the SNIA	Decentralisation of the decision making process for agricultural research with participation of Fundaciones Produce and COFUPRO and INIFAP's change from being a public research organisation under SAGARPA to being a public centre to serve any research demand in 2003 Persistent inadequacy of the reward system for agricultural research in the university system and INIFAP (i.e. SNIA) to favour third stream university activities and technology transfer Limited participation of some universities and industrial research centres (e.g. UAAAN, ITESM Campus La Laguna, COLPOS Cárdenas and CIATEJ)
Changes in the financial development organisations	FIRA became a financial organisation and abandoned agricultural development activities in 1998. New financial instruments support mainly large farmers and agro industries acting as 'para-financieras' to support the integration of small dairy farmers (e.g. Sigma Alimentos and Nestlé); Financiers Rural and FIRCO support agricultural infrastructure development for small producers
Changes in the activities of LICONSA	Contradictory results: LICONSA abandoned dairy development activities (1997), and has struggled with regulation of the market for NFDM and fresh milk since 2002 with PALN to improve the collection of milk but distorting the market price and supply of fresh milk
Changes in milk price regulations	SAGARPA liberalise milk price control in 1996, which increased the incentives for milk production for dairy farmers, making intensive milk production systems respond faster

Source: Author´s elaboration from Appendix I.

[50] None of the interviewees mentioned that the CSPBL has helped with the planning and the integration of the value chain of the MDS. Furthermore, searching for representatives and attendance at the CSPBL forums from the list on the website since 2005 http://www.sagarpa.gob.mx/Dgg/sisprodbol.htm shows very low participation from among the large dairy processors (e.g. Lala, Alpura and Lechera Guadalajara), except for Nestlé.

[51] PIAL (Patronato para la Investigación Agropecuaria Lechera de La Laguna) is the Patronage for Research in Dairy Livestock Production in La Laguna.

[52] The Mexican government amended the Mexican Constitutional article 27, which fostered privatisation of previous agrarian reform lands. From 1917 to 1991, agrarian reform had resulted in the re-distribution of roughly 50% of Mexican rural land area to 'ejidos' (i.e. groups of collective farmers called 'ejidatarios' entitled to a particular parcel of land that could not be sold, but only passed to their heirs). The amendment allowed the selling of landholding rights of 'ejidos' to create a more efficient market for land, i.e. privatisation of the land. In this way, smallholdings could be purchased or consolidated by those with larger resources and the ability to produce efficiently. Overall, there are still many smallholders growing subsistence crops of corn and beans, and little investment in a sector that is considered backward and high risk (Austin, Chu et al. 2004).

2.4 Modernisation of Mexican milk production systems

In order to understand the modernisation processes of the MDS for milk production, four features are important. First, the technological systems for milk production and their technological components (see Table 2.3), included in farms lead to innovation processes on farms, which are generally associated with higher capital investment; and/or the improvement of management practices define the different milk production systems as well as their productivity and economic efficiency (subsection 2.4.1). Second, these milk production systems are also associated with the climatic, economic and social factors considered in subsections 2.4.2 and 2.4.3. Third, these factors influence the integration of the value chain, i.e. dairy farmers and dairy processors (subsection 2.4.4). And fourth, Mexican government agencies have set up two main technology transfer programmes that have affected changes in milk production (subsection 2.4.5).

2.4.1 Technological systems for milk production

Mexican milk production employs a wide array of technologies within two closely intertwined farm subsystems, each with two central technological components (Table 2.3).[53] The subsystems are: a) the organic subsystem, and b) the farming subsystem. The productivity of farms depends largely on how the subsystems (first column) adapt technological components (second column) and the extent to which they use and integrate technologies (including managerial processes) leads to different types of milk production systems (third column).

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[53] These arrays of farm subsystem and technological components were based on the findings of this research for the types of milk production systems suggested by SAGARPA (2000). They may not be strictly what veterinarians, agronomists, dairy technologists, etc. would define. However, the author found it useful to classify them in this way in order to analyse the evolution of capabilities in a systematic way.

Table 2.3 Mexican milk production systems and associated technological components

Farm subsystems	Technological components	Types of milk production systems
Organic subsystem[54]	Cow genetics Herd management: animal reproduction, nutrition (feedstock production) and health	Specialised, intensive or Holstein system Semi-specialised and family system Non-specialised, extensive system, or dual-purpose system
Farming subsystem	Milking and chilling subsystem Integrated mechanical milking systems and hygiene practices Chilled tanks and chilled transportation to dairy facilities	

Source: Author's proposal.

The following describes in more detail the farm subsystems and their technological components, which will help in understanding the changes of routines and capabilities in the dairy regions in Chapter 5.

Organic subsystem. Cows' genetics and herd management

The Mexican dairy herd is comprised of several breeds. Specialised dairy or English and European cattle (i.e. Bos *Taurus Taurus*) (e.g. Holstein, Brown Swiss and Jersey) are mainly used for specialised milk production systems in the arid and semi-arid and increasingly in the temperate areas. Crossing of these specialised breeds with Indian cattle (i.e. Bos *Taurus Indicus*) (e.g. Zebu) results in cows with the phenotype F1, which improves milk yields in unfavourable climates, e.g. tropical regions. Further crossing of hybrid cattle (a new generation of a crossbreed Taurus-Indicus) is necessary to achieve cattle crossbreeds referred to as 3/4 and 5/8 for better performance in tropical regions (e.g. Tabasco) (Cunningham and Syrstad 1987). The development of these crossbreeds for tropical regions was carried out by INIFAP La Posta in the state of Veracruz and Nestlé in the late 1980s (Castañeda Martínez 2005; Enrigue Loera 2005) (see Appendix I, section 1.2; and in Chapter 2, section 2.4.5).

The management of cows' reproduction cycles defines the milk production period and the productivity of the herd. Traditionally, the reproduction cycle was not controlled and stud bulls were used. Modern methods involve heat detection (i.e. oestrus period) in the cow, and the use of artificial insemination (AI) practices and sometimes embryo implantation, sexed semen use (to ensure more heifers), and control of reproduction via

[54] This concept refers to animal husbandry or animal science, referring to the practice of breeding and raising livestock. Here they are separated to distinguish the different systems of milk production.

lactation period (i.e. days of milk production per year). Each farm can design its own milk production cycle to match demand. The choice of production cycle is affected by the seasons[55] (i.e. availability of water and grass, and temperature) and the health of the herd. The use of technologies in the reproductive cycle makes milk production a more controlled process.

The management of animal health includes procedures to prevent and/or eliminate diseases in the herd (i.e. tuberculosis, brucellosis, paralytic rabies, BSE, mastitis, and foot-and-mouth disease), which improves safety for the herds, labourers and consumers, and increases herd productivity – the healthier and more appropriately fed and bred the herd, the more productive the system.

Management of animal nutrition refers to the herd's feed regime (feedstock administration).[56] This includes choices about proportions of grains in silage (i.e. mixes of corn, oats and sorghum, baled hays, and fermented slurries produced from them), leguminous plants (i.e. alfalfa) and protein pastes used mainly in specialised and semi specialised systems, and the use of grazing land, especially in the tropical regions. Although general prescriptions regarding content and quality of dry matter (i.e. protein, carbohydrates and minerals) in feedstock are available, dairy farmers design their own cattle diets and feeding procedures, depending on the availability and economics of the raw materials, based on either professional advice or relying on personal experience.

Farming subsystem. Milking and chilling subsystems: milking routines, machinery and chilling systems at the farm, and the refrigerated transportation to the processing facilities

[55] Milk production peaks during the rainy season causes an over supply of milk in the market with lower prices paid to the producers. This annual phenomenon has resulted in limited milk availability during other times of the year due to the lack of infrastructure for the drying of milk, and high storage costs. Seasonality of production is more common on dual-purpose production and to a lesser extent in semi-confined farms and is associated with availability of pastures for feeding the cattle.

[56] Feedstock availability, quality and supply constitute a separate research enquiry, and their analysis is outside of the scope of this research. They are treated here as a component of herd management and comprising improvements in agriculture production of alfalfa and grains and development of intensive grazing systems in tropical areas.

Practice varies from one to three milking[57] per day depending on the quality of the feed (e.g. intensive grazing, use of alfalfa, forage, silage, and supplements) which affect the conversion of feedstock to milk (Salas Quintanal 2002). Twice a day milking is normal in intensive systems (e.g. La Laguna) and some semi intensive and family systems in temperate and tropical regions are increasingly adopting it (Aranda Ibáñez 2005; Cervantes Escoto 2005; Guiot García 2005; Luna Prieto 2005).

Milking can be manual or mechanical depending on the degree of integration of automatic milking parlours on the farm. The milk is transferred to storage ideally in a closed pipe system to conserve the quality of the milk. Chilling systems including the pipes and tanks operate at 4-6°C to prevent bacteriological degradation. Chilled tank to transport milk is a complementary equipment that preserves the milk quality until it is processed (NDFAS Guidelines).[58]

In addition to the milking and chilling systems, the cleanliness of cows and the use of hygienic milking practices all add to the production and conservation of safe, high quality milk and increase the efficiency of successive industrial processes. High quality milk increases the shelf life of pasteurised fresh milk and produces higher value dairy products such as yogurt, pro biotic drinks, and some mature cheeses. Lower quality milk can be used for the production of UHT, evaporated and condensed milk, artisan cheeses and powdered milk. In these applications, thermal processes reduce the quantity of live bacteria in final products, despite a higher initial level. In general, dairy processors prefer the lowest possible level of bacteriological activity. It has been claimed that incorporating more technology (e.g. better feedstock, mechanical milking systems, etc.) on the farm will result in higher quality milk[59] and increase the productivity of the cows. However, these practices raise the operating costs, although higher quality milk may be sold at a higher price, perhaps offsetting its higher costs of production and (ideally) will improve the profitability of the farm, which may also

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[57] This practice of milking three times is increasingly used in intensive systems in La Laguna (Aguilar Valdés 2005; Luévano González 2005; Salas Quintanal 2005).

[58] NFDAS (National Dairy Farm Assurance Scheme) website: http://www.ndfas.org.uk/ (September 20, 2006).

[59] The quality of milk from the farms is defined mainly by three variables: fat and protein content, dictated by the genetics of the cow, and feed quality; the bacteria and somatic cell counts in milk depend on the health and hygiene practices and the cleanliness of the cows and their udders. Eventually, milk quality depends on the length of time before it is pasteurised or processed; therefore, chilling systems are required to preserve quality (Cervantes Escoto 2005; Chombo Morales 2005; García Nuñez 2005).

enable larger scale production. The heterogeneity in the use of technologies leads to a wide variation in farm productivity, especially among the semi-specialised, family and dual-purpose systems where non-specialised cows, manual milking and non-integrated chilling systems are still common.

2.4.2 Milk production systems and associated climatic regions

There are dairy farms in most states of Mexico. The climatic [60] as well as the technological diversities in the country make it difficult to characterise dairy regions (Dávalo Flores 1997; González Padilla 1999). However, three main technological milk production systems (see Table 2.3) have been identified, associated with three specific climatic regions (SAGARPA 2000) (see Figure 1.2) and the socio economic conditions of these regions. They are:

(1) specialised, intensive or Holstein systems, found mainly in arid and semi arid regions (i.e. most of the northern states of Mexico) and increasingly in temperate regions (i.e. the central states);
(2) semi-intensive and/or family systems [61] found in temperate and tropical regions (i.e. the west coasts of some states), and
(3) non-specialised, dual-purpose or extensive milk production systems found mainly in tropical regions (the southern east states and some west states).

Larger farms with more homogeneous and specialised technologies occur mostly in the arid and semi-arid regions. They have evolved based on more intensive use of technology and capital (Martínez Borrego and Salas Quintanal 2002) described in 2.4.1. On the other hand, there are numerous small family farms with heterogeneous technologies in the temperate and tropical areas.

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[60] This is a simplified way of looking at the climatic conditions of the country; however, there are microclimates within states and regions. For example, Jalisco has heterogeneous milk production systems, which include semi-specialised and specialised systems in Los Altos (and other parts of Jalisco) and dual-purpose systems on the Pacific coast (de la Torre Sánchez 2005; Reynosa Campos 2005).

[61] SAGARPA (2000) suggested four systems of milk production. However, semi-specialised systems and family systems are included in the same category in this research. The main difference between them is herd size. Semi-intensive systems generally have larger herds than family farms, as suggested by Martínez Borrego, Salas Quintanal et al. (2003).

Chapter 5 discusses for three specific regions the factors that influenced and constrained the development of capabilities, which are the cases for this research.

a) Specialised, intensive or Holstein systems

These specialised systems have been adopted since the middle of the last century in La Laguna region and increasingly are being used in other regions. They involve dairy cows and a complete feedstock menu, i.e. alfalfa, grass pasture and forage. These systems are industrial systems, and involve mechanical milking and integrated chilling systems for large volumes of high quality chilled milk, which are commercialised for dairy industrialisation. These systems require specialised knowledge and division of labour (e.g. veterinarians to deal with the organic subsystems, milking parlour or barn designers, farm control system specialists,[62] logistics systems for milking, and milk preservation and collection systems), and a well articulated market of feedstock. They also require large investment (i.e. generally large herds) and working capital for their operation (Madero Gámez 2005).

The specialised model has expanded to several states (e.g. Jalisco, Chihuahua, Estado de México and Querétaro) (Martínez Borrego and Salas Quintanal 2002). The model was imposed by large domestic dairies and MNCs and was supported by Mexican agricultural organisations as a technological package analogous to the Green Revolution (del Valle Rivera 2000). The Green Revolution is a somewhat deceptive description (Goldberger 2008) as the same package is used in most advanced countries. It has succeeded because of increased demand for larger quantities of high quality milk by the large dairy firms and favourable input prices, e.g. electricity to chill the milk and feedstock production, much of which uses resources that came from oil exports. Its implementation was supported by suppliers of inputs such as semen, milking systems, etc., which also provide technical support, and by government programmes providing resources for improving the infrastructure to modernise farms and incorporate chilling systems for milk collection (Alvarez Macías 1999; González Padilla 1999; del Valle Rivera 2000; Cervantes Escoto 2003).

[62] Current control systems include sophisticated electronic devices to measure the intake of feed per cow and yield or productivity per cow, and customised software to support herd management (i.e. animal reproduction, nutrition and health) to increase the overall productivity of the farm (Madero Gámez 2005).

The adaptation of this technological package to local conditions has enabled large dairy farmers to compete in the global market (see La Laguna case). However, features of this package are still evolving in many regions (e.g. see case studies of Los Altos and Tabasco in sections 5.2 and 5.3 in Chapter 5). Expansion of this system may endanger its economic sustainability because of the increased demand for water in the production of feedstock (mainly alfalfa) and for cleaning on the farm. The demand for water has already created competition over supplies in arid and semi-arid regions (e.g. La Laguna) (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000; Salas Quintanal 2002).

b) Semi-specialised and family systems

These systems are largely traditional and have been in use for over a century in agriculture and livestock production regions. Their main features include limited capital and technologies (smaller herds than in the specialised system) and intensive use of family labour. Many dairy farmers using these systems are beginning to imitate the intensive model and adapt it to their needs (e.g. see the case of Los Altos). These systems are very important from a social perspective, because they are a major source of employment for family members (although not necessarily wage labour) in most rural areas of central and south Mexico (Cervantes Escoto 2003; Cervantes Escoto 2003; Muñoz Rodríguez, García Muñiz et al. 2003).

c) Non-specialised, extensive systems or dual-purpose systems

Dual-purpose systems refer mainly to small family farms with crossbred herds found in tropical regions. They are considered primitive compared to the intensive model. Highly productive dairy cows suckle calves (reared for beef production) and surplus milk is traded (Muñoz Rodríguez, García Muñiz et al. 2003; Alvarez Macías 2005). They are associated with lower levels of capital investment than the other two systems but are increasingly using artificial insemination, intensive grazing systems (improved grasses and grazing practices), and introducing automatic and chilling systems (following the intensive model). Alvarez Macías (2005) argues that milk production is not an 'extractive activity', nor is it a 'subsistence activity' because it no longer depends on natural grazing but requires intensive agriculture, where in certain areas cattle production has exhausted and eroded the land. Furthermore, it has been increasingly important for economic sustainability in some regions (e.g. Chiapas, Veracruz and

Tabasco states). However, a large amount of their milk production is commercialised through 'ruteros'[63] to produce artisan cheeses and other dairy products (see the cases of Los Altos and Tabasco).

Similar to semi-intensive and family systems, the dual-purpose systems are very important socially because of the employment they generate in rural regions, although they have lower productivity compared with the other two systems. However, milk production is concentrated in specialised dairy farms with large herds, which in 1998 produced approximately 80% of the milk from less than 20% of the cows in the country (see Table 2.4).

Table 2.4 Evolution of Mexico's dairy livestock

Year	Milk production source, %		Livestock inventory, %	
	Specialised livestock	Non-specialised livestock	Specialised	Non-specialised
1972	56	44	19	81
1980	56	44	17	83
1989	55	45	18	82
1992	61	39	12	88
1998	81	19	17	83

Source: Author's elaboration of data from Hernández Laos and del Valle Rivera (2000); SAGARPA (2000).

2.4.3 Economies of scale

In 1991, 90% of an estimated 70,000 dairy farms were small and had less than 50 cows (see Table 2.5).

Table 2.5 Structure of Mexican farms 1991

Size of the farms	% of the units of production	% of the herd
Less than 10 cows	77.2	27
10 to 49 cows	20.2	37
50 to 500 cows	2.6	26
More than 500 cows	0.2	10
Total of ~70,000 (1)	100.0	100

(1) These farms account for 8.2 million animals and 300,000 farm hands. The forage for this production is produced in around 6 millions ha of land; 1.5 million ha located in the arid and semi-arid regions and the remainder in the tropical regions.
Source: González Padilla (1999, p 302).

[63] 'Ruteros' or intermediaries are the brokers who collect milk for commercialisation mainly from small dairy farmers and sell it to dairy processors. Their tanks generally were not chilled. They have been criticised for their negotiating power in terms of the prices paid to farmers, which gives them most of the profit in the value chain. They negotiate milk prices with the dairy processors and deduct the cost of transportation and their profit before paying the farmers, who generally receive less than expected. Their role has been described as very influential especially in the temperate and tropical regions, where small farmers cannot sell milk direct to the processors (Cervantes Escoto 2005).

In 2005, the number of farms had decreased with those remaining having more animals[64] (Enrigue Loera 2005; Nuñez Hernández 2005; Ruíz López 2005). The gap in profitability between the specialised and the non-specialised systems is large in the regions. Specialised systems get higher economic returns than the non-specialised and dual-purpose systems. However, in terms of efficiency in the use of resources, dual-purpose systems in tropical regions do better than specialised ones in La Laguna and Los Altos (Odermatt and Santiago Cruz 1997; FIRA 2001).

2.4.4 Integration of the value chain: dairy farmers and dairy processors

Since NAFTA, the integration of milk production and processing has been increasing to challenge the increased imports of dairy products (del Valle Rivera 2000; Cevallos Urueta 2005). The economic reasons behind this integration include a reduction in transaction costs within systems (Hernández Laos and del Valle Rivera 2000). Integration also promotes a stable supply for the dairy processors of high quality chilled milk, therefore, creating a virtuous cycle (Cervantes Escoto 2005) which allows better planning of production and marketing (Arista Puigferrat 2005; Arrieta González 2005) and attracts investment in milk production (Falcón Estrada 2005).

Large domestic and MNC dairy firms have led this integration by establishing supplier relationships with dairy farmers in order to promote the modernisation of milk production in most Mexican dairy regions (Alvarez Macías 2005; Cervantes Escoto 2005; del Valle Rivera 2005). They impose purchasing conditions for fresh milk (i.e. price, quality and amount) and use additional supportive strategies.

These strategies include: a) providing economic support to farmers (i.e. loans that are repaid with milk) to improve milking and chilling systems; b) providing technical support through their technical departments; c) facilitating the generation of supply networks with MNCs and other suppliers of semen, feedstock, machinery and equipment, etc.; and d) providing training courses for dairy farmers to increase productivity and profitability of the farms through cost reduction and improvement of

[64] This was based on a consensus among interviewees. There are no updated data on the number of milk production units after the Agriculture Census of 1991. There was an Agriculture Census in 2007 but the data were not available at the time of this research.

milk production practices (i.e. technical and managerial skills) (Cervantes Escoto 2005; Enrigue Loera 2005; Godínez Vázquez 2005; Rodríguez Gómez 2005).

It has been argued that large dairy firms have imposed the costs of modernisation on the farmers through their milk purchasing practices and do not share the risks associated with seasonal production. As a result, small farmers were unable to invest in and improve their processes or reorganise to integrate into the value chain to satisfy the demands of the large firms and so went out of business, creating social problems (Alvarez Macías 2005; Cervantes Escoto 2005; del Valle Rivera 2005; Luévano González 2005; Rodríguez Gómez 2005). The situation was made worse by the economic crisis that has persisted since 1995,[65] which has reduced the demand for dairy products and investment in the sector (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000), except for some of the largest farmers and firms (e.g. Lala and Sigma Alimentos) (Hernández Astorga 2005; Quintanilla Alvarez 2006).

Despite being criticised for the imposition of the intensive technological package, the large dairy processors are collecting increasing amounts of high quality chilled milk from the regions (e.g. Nestlé and Alpura collecting milk in La Laguna and Los Altos).

Some successful cases of integration of small dairy farmers chilling milk, which achieved economies of scale, are Alimentos La Concordia in 1994 and PROLEA (see Table S5.4) in 1986 in the Los Altos region (Ramírez González 2005a), JAMALAC[66] (Alonso Capetillo 2005; Ortíz Vera 2005; Valdivia Valentín 2005) in 2003 in Veracruz, and artisan cheese producers (Asociación de productores de queso 'de Poro') in 2002 in Tabasco (de la Peña Marshall 2005). However, many efforts have failed. One of the main reasons for these failures has been the changes in policies of the dairy firms and the resistance among farmers to work in groups (Chombo Morales 2005; Pérez Burgos 2005; Ramírez González 2005a) (see the Los Altos case in section 5.2).

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[65] Mexico suffered major devaluation of the Peso due to economic crises in 1983-1984, 1987-1989 and 1995-1996. These financial crises put the entire Mexican economy at risk, and affected the development of the dairy industry.

[66] JAMALAC is an entrepreneurial project involving a group of small dairy farmers, who set up a facility to produce yogurt in 2003 using their own resources and resources from Alianza para el Campo, FIRA and FIRCO (Alonso Capetillo 2005; Ortíz Vera 2005; Valdivia Valentín 2005).

The result is that the degree of integration is greatest in systems where specialised and semi-specialised milk production systems are employed to produce high quality chilled milk, and increasingly in family and dual-purpose systems.

2.4.5 Technology transfer programme

The main programme designed by SAGARPA and INIFAP to transfer technology for milk production from INIFAP research centres to support capabilities building within farms is DEPAI through specific projects and GGAVATT groups (Vázquez Gómez 2005; Villamar Angulo 2005).

DEPAI (i.e. Desarrollo de Proyectos Agropecuarios Integrales) is the largest integrated extension activity that provides technical assistance and technology transfer through its trained extension agents to farmers and cattlemen, which some of whom use the GGAVATT method[67] (see Appendix I, section 1.2).

Each DEPAI project consists on a strategic planning project coordinated by a DEPAI extension agent to help farmers to establish a vision for the future of the unit of production and the activities required to reach it. It is a two-way learning process. It starts with a two-day session. The first day's activities focus on diagnosing: a) animal health, production and nutrition, b) technology use, c) supply chain of inputs for production, d) finance management, and e) business development, on the farm. The second day focuses on developing the plan of improvement activities: a) using diagnostics to detect problems and needs, b) the setting of priorities to solve problems, and c) agreement on actions between the farmers and extension agent to achieve the aims. DEPAI's extension agents and dairy farmers do monthly assessments of the plans and the achievements within the units of production for at least the following two years (Arellano Leaño 2005; Valencia Zarazúa 2005).

GGAVATT (Grupos Ganaderos para la Validación y Transferencia de Tecnología Pecuaria), a method developed for validation and technology transfer by INIFAP to cattle farmers, is in INIFAP's national programme (PRONAVATT, Programa Nacional

[67] It was estimated to have approximately 1,200 extension agents, 20% of them working with livestock production using the GGAVATT method (Alvarez Macías 2005).

de Validacion y Transferencia de Technología) (Alvarez Macías 2005). It was developed by an INIFAP Veracruz research group in La Posta, Paso del Toro research station in Veracruz state in the early 1980s (Pérez Saldaña 2005). It aims to increase the capabilities of groups of cattle farmers working together with extension agents to improve their productivity to make their farms economically and ecologically sustainable (Román Ponce 2005). INIFAP La Posta together with SAGARPA state offices, the associations of cattlemen, supported by the University of Veracruz and the professional association of veterinarians (i.e. CMVZV) have trained extension agents from DEPAI and other organisations to implement the GGAVATT method around the country (Alpírez Mendoza 2005; Blanco Ochoa 2005; Valdovinos Terán 2005; Zilli Debernardi 2005).

The GGAVATT method has been one of the most successful technology transfer methods to develop capabilities in farms[68] in tropical regions[69] and became the official technology transfer method in the state of Veracruz (Remes Cabada 2005; Ruíz Arriaga 2005). Around 60% of the groups using the GGAVATT method are dual-purpose dairy farmers and 10% are specialised and semi-specialised dairy farmers. However, diffusion of the use of the method has been difficult because of the limited number of extension agents (one to every 20 farmers) and limited budget to train agents to assist farmers (Vázquez Gómez 2005).

The GGAVATT group method consists of four stages. The first stage involves the formation of a GGAVATT group of up to 20 farmers and an extension agent (or DEPAI agent). Together they find the problems on farms operations and jointly they agree solutions and make commitments to implement the solutions. Second, farmers apply the technological package provided by the extension agents and establish economic and

[68] According to Román Ponce (2005) some of the mechanisms that support learning processes and develop capabilities are: a) collective learning by sharing experience among the members of the groups to create endogenous knowledge; b) imitating best practices from advanced farmers; c) codifying information that helps to control the technological processes within farms; d) multiple feedback loops for learning, from the researchers and extension agents to the members of the group and vice versa; e) speeding up the decision-making processes to implement changes in farms; f) self-driven developing processes supported by shared values (e.g. trust, help, imitating); and g) committing and delivering results to encourage other group members to imitate and improve their farms' practices.

[69] For example, the emergence of JAMALAC, a dairy processor, was the result of organizing to improve the productivity of the cows of dairy farmers in Cotaxta in the state of Veracruz (Alonso Capetillo 2005; López López 2005); and the dairy farmers of the Asociación Ganadera Local de Ozuluama, AGLO (2005) in the state of Veracruz report that farmers have improved the productivity of the cows from 1-3 litres per day to 10-13 (del Angel Juárez, Molina del Angel et al. 2005).

productions records to follow up in every unit of production. These stages last between 12 to 14 months. Third, the extension agent carries out intensive training on the adoption and implementation of the technological package provided by INIFAP. The overall project lasts for two to three years more. Fourth, at around the fifth year of the GGAVATT group work, farmers carry out specific activities for commercialisation and look at capital investment. Farmers commit to following at least 70% of the practices suggested by the extension agents and to recording their activities to improve their decision-making (Galindo González 2001).

It has been argued that GGAVATT has limitations such as a difficulty to systematically assess the results because of the length of the learning process (2-5 years). Another limitation is keeping the extension agents sufficiently updated to attend to the demands of farmers (del Angel Juárez, Molina del Angel et al. 2005; González Díaz 2005; Lagunes Ortega 2005). The most important limitation however, is that it does not include the development of capabilities to commercialise products (Alvarez Macías 2005; del Valle Rivera 2005).

In both methods, it is believed that the main learning mechanisms are learning by doing and imitating from successful farmers and/or farmers' leaders, who have adopted specific practices and achieved better results and their practices are copied and imitated by members of the groups (Pérez Saldaña 2005; Román Ponce 2005).

2.5 Modernisation of Mexican dairy processing

The early adoption of the intensive model for milk production in La Laguna in the 1950s increased the supply of high quality chilled milk for industrialisation. However, milk industrialisation had begun in the 1930s with the arrival of Nestlé (a Swiss firm) and Carnation (an American firm). These companies started the globalisation of the dairy industry in Mexico (Barkin 1987; Teubal 1987).

Nestlé, the most important MNC in the MDS started importing and selling dairy products (as well as other processed foods) and eventually set up dairy production facilities in the early 1930s in Jalisco (see Appendix I, section 2.1). There were also some important changes to public health legislation in Mexico because of brucellosis and tuberculosis outbreaks;[70] the Mexican government passed a law that obliged farms to relocate away from urban areas and sell only pasteurised milk in glass bottles in 1925 (Salas Quintanal 2002). This change prompted the emergence of several small regional pasteurisation firms, which in the 1990's large dairy firms bought some of them in response to pressure to become more profitable (García Hernández, del Valle Rivera et al. 1997; García Hernández, Martínez Borrego et al. 1999; del Valle Rivera 2000).

This modernisation after NAFTA (which we refer to as the third stage), also resulted from increasing use of technologies to modify dairy processes and produce new dairy products (Canedo Parra 2005; Guerrero Jiménez 2005; Otaduy 2005). These changes have transformed the structure of the industry and have co-evolved with changes in the eating habits of the population and its income (Euromonitor 2005). Higher income groups demand high value dairy products (del Valle Rivera 2000).

A sample of the technological components of dairy processing that have been improved on dairy firms in order to develop new products and processes and meet new standards are shown in Table 2.6.[71] Note that the main link in the value chain is the availability of large volumes of high quality chilled milk, essential for the preparation of long-shelf life fresh milk, yogurts and cheeses[72] (Alvarez Barrera and Ji 2003).

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[70] Brucellosis and tuberculosis are transmitted to humans through contaminated (unpasteurised) milk and dairy products, and by direct contact with infected animals (cattle, sheep, goats, pigs, camels, buffaloes, wild ruminants, and seals) http://medilinkz.org/HealthTopics/Diseases/zoonoses/brucellosis.htm and http://www-micro.msb.le.ac.uk/video/Mtuberculosis.html) (September 25, 2006).

[71] The array of dairy products and associated technological components was developed based on the thesis research findings and the author's experience as a food technologist. Specificities of the technological changes in firms were not provided by the interviewees for reasons of confidentiality. This classification might not strictly coincide with that of a dairy technologist. However, it is considered useful to analyse the evolution in a systematic way.

[72] Quality of milk for dairy production has to ensure lactic culture action (fermentation processes) and requires the following criteria for raw fresh milk to be met: low bacteria count, free from antibiotics, sanitising chemicals, mastitis, colostrums, and rancid milk; and no contamination from bacteriophages. University of Guelph website http://www.foodsci.uoguelph.ca/dairyedu/yogurt.html, (August 25, 2008).

Table 2.6 Mexican dairy products and associated technological components

Dairy products	Technological components
Fluid milk, long shelf-life in Tetra Pak™ and UHT milk in Tetra Brick™ and flavoured (smoothes) and powdered milk	Treatment of milk (quality of milk, temperature and timing, dehydration and aseptic processes) Ingredient preparation: (FDM, NFDM, whey and lactose) Stabilizing procedures: gelatine, carboxymethyl cellulose, locust bean Guar, alginates, carrageen, whey protein concentrate, etc. Flavouring: glucose or sucrose, high-intensity sweeteners (e.g. aspartame), fruit preparations, natural and artificial flavouring and colouring Packaging (shelf-life, aseptic packaging, materials and processes)
Cheese: unripe and mature	Treatment of milk (quality of milk, temperatures and timing) Stabilisation procedures: additive use (calcium chloride, nitrates, colour, hydrogen peroxides, lipases) Inoculation and milk ripening (lactic acid bacteria and pH regulation) Coagulation (enzyme, acid, heat-acid) and curd treatment (cheddaring, curd separation and cutting) Cheese ripening (temperatures and timing) Packaging (shelf-life, materials and processes)
Yogurt: stirred, set, drinking, pro-biotic drinks, fruit-on-the-bottom, soft-serve and hard pack frozen, continental, French and Swiss	Treatment of milk (quality of milk, temperatures and timing, aseptic processes) Ingredient preparation: (FDM, NFDM, whey and lactose) Stabilising procedures: gelatine, carboxymethyl cellulose, locust bean Guar, alginates, carrageen, whey protein concentrate Flavouring: glucose or sucrose, high-intensity sweeteners (e.g. aspartame), fruit preparations, including natural and artificial flavouring and colouring Fermentation processes: started culture (blends of *Streptococcus salivarius* subsp. *thermophilus*; and *Lactobacillus delbrueckii* subsp. *bulgaricus*) and manufacturing processes (temperature, timing, standardisation, etc.) Packaging (shelf-life, aseptic packaging, materials and processes)

Source: Author's elaboration of dairy product information from the websites of the main Mexican dairy firms; and dairy technology information from Alvarez Barrera and Ji (2003), Villegas de Gante (2003) and the University of Guelph websites: http://www.foodsci.uoguelph.ca/dairyedu/yogurt.html; http://www.foodsci.uoguelph.ca/dairyedu/cheese.html (August 25, 2008)

2.5.1 Transformation of the dairy processing industry

There are no official statistics on the number of dairy firms, installed capacity or used capacity after 1996 (del Valle Rivera and Alvarez Macías 1997). However, we can derive some indications of what happened during modernisation of the MDS. First, the oligopoly structure of the industry has changed very little. Although the number of dairy facilities appears to be similar to the 1993 level, the concentration of industrial activities has increased (i.e. CR4[73] higher than 30%) since NAFTA (Hernández Laos and del Valle Rivera 2000). There is also more concentration by large and medium sized firms, which dominate milk processing (e.g. Lala in pasteurisation of milk, Nestlé in dehydration of milk and Sigma Alimentos in yogurt production), and small dairy firms, which dominate the production of artisan cheese and milk-based confectionary (see Table 2.7).

[73] Concentration ratio of the industry.

Table 2.7 Structure of Mexican dairy firms

Firm activities	1993	1998
Pasteurised and packaged milk	94	98
Powdered, condensed and evaporated milk	17	17
Producers of cheeses, butter and milk cream*	1396	1390
Milk-based confectionary	357	359
Total	1507	1505

* This includes small dairy processors that produce artisan cheese and cream 'in bulk' called 'queserías and cremerías'.
Source: Author's elaboration of data from del Valle Rivera (2000) p 281.[74]

Second, employed capacity increased from 46% (1996) (see Table S2.2) to 70% for pasteurised milk and 60% for other dairy processing in 2004 (SIAP 2005). Third, the growth of the main dairy firms has occurred via processes of geographic expansion and operation. While Lala acquired dairy facilities in other states (e.g. Parmalat facility in Los Altos region in 2004) (Hernández Astorga 2005), Lechera Guadalajara invested in creating dairy facilities in Los Altos (i.e. Alimentos La Concordia) in 1994, and in the states of Nuevo León and Sinaloa in 2005 (Canedo Parra 2005). In the case of Sigma Alimentos, it acquired the New Zealand México, which owned a traditional cheese producer in Hidalgo (i.e. Lácteos Finos S.A.) to expand its market in Mexico with the known brand 'Nochebuena' (Quintanilla Alvarez 2006). Fourth, as well as milk production, milk industrialisation involves big differences in technological and managerial production systems among large and small firms. Large and medium sized firms (e.g. Lala, Alpura, Sigma Alimentos, Danone and Nestlé, comprise approximately 8% of total firms) use advanced technologies,[75] and have created most of the added value in the sector (Hernández Laos and del Valle Rivera 2000; SAGARPA 2000). Nevertheless, 10-30% of milk is sold unpasteurised and used to produce artisan dairy products[76] (see cases of Los Altos and Tabasco).

[74] The total number of dairy firms is estimated at 11,411 in 1998 and includes producers of ice cream and frozen dairy preparations, which account for 9,906 producers (del Valle Rivera 2000), which are not included here.
[75] Dairy researchers (Alvarez Barrera 2004; Chombo Morales 2005; Quintanilla Alvarez 2006) and practitioners with more than 20 years of expertise in dairy production argue that medium and large dairy firms have 'state of the art' technologies acquired through alliances with foreign firms for technology transfer (i.e. Lala and Sigma Alimentos); and participation of suppliers of dairy equipment, which provide the latest technology (Aguirre 2005; Callieri 2005; Hernández Astorga 2005; Ortíz Vera 2005; Reinert Fernández 2005).
[76] Unpasteurised milk might pose a health risk to the population. However, there are many dairy regions in Europe, which are based on the production of cheese with unpasteurised milk, but it should be noted that they rely on milk from healthy herds.

In summary, the modernisation of the MDS industry has followed international trends in milk production (Holstein model) (Alvarez Macías 2005; Cervantes Escoto 2005; Godínez Vázquez 2005; Madero Gámez 2005) and dairy processing and consumption (e.g. yogurt, cheese, flavoured milk and yogurt drinks) (Alvarez Barrera 2004; Aguirre 2005; Hernández Astorga 2005; Téllez Abaunza 2005).[77] However, the MDS is still probably less competitive than in the US (Hernández Laos and del Valle Rivera 2000) and the EU countries. Mexican milk production, productivity per cow, size of the herd, and dairy production (except cheese) have grown faster than in the US and EU,[78] but average productivity per cow is still lower than in these areas. Overall, however, Mexican milk production costs were lower than those in the EU and slightly lower than in the US in the period from 1999 to 2003 (see Table S2.3).

2.6 Milk and dairy production distribution systems

Modernisation of dairy distribution has followed the evolution of the international retail sector. This sector has been restructured since NAFTA with the consolidation of MNCs (e.g. Wal-Mart, Carrefour, Costco, K-Mart, and Auchan), which accounted for higher shares of the retail market at the expense of small and medium sized retailers and family businesses. Only 15% of the distribution of pasteurised milk and a large percentage of the production of dairy products is through large retailers; 85% of pasteurised milk is distributed by family-run (mom and pop) shops and convenience stores[79] (Soltero Gardea 2005). Therefore, innovation in logistics by most dairy firms constitutes an important change in the overall functioning of the MDS.

This strong partnership between MNC retailers and large domestic and MNC dairy processors have likely been responsible for the demise of many small retailers, processors and farmers (Hendrickson, Heffernan et al. 2001) (as in other oligopolistic industries). Although there are some social and employment implications from these changes, they may not have affected the efficiency of the distribution system for the

[77] There was no evidence that other industrial milk products such as isolated milk proteins, caseinates and lactose have been developed (Alvarez Barrera 2004).

[78] The slow rate of growth of milk production in the US and EU (see Table S2.3) could be explained by the need to maintain high international prices for NFDM and full fat dry milk (FDM) and other dairy products without affecting the income of small farmers in developed countries (Beitel 2005).

[79] Note that the growth of OXO and 7Eleven and other chains of convenience shops are displacing family run shops (Soltero Gardea 2005).

final consumer. Consumers may be better off because of convenience foods with shorter preparation time and healthier and more functional products are the trends in the food packaging industry, a trend that Mexican dairy producers have followed closely (Euromonitor 2005). However, there are some exceptions to this trend. For instance, Mexican consumers favour soft fresh and semi-mature cheeses over mature cheeses (Country-Monitor 1999). Artisan cheese and cream 'in bulk' are still distributed through traditional local markets (Chávez 2002; Reardon and Berdegué 2002; Meyer 2003). However, since NAFTA, the market is more sophisticated and cheese imports have increased (see Table 2.8) despite the persistent economic crises. This suggests further increases in dairy consumption would occur if the Mexican economy were to grow more rapidly[80] (Hernández Laos and del Valle Rivera 2000).

Table 2.8 Trade balances of Mexican dairy products, 1994-2004

Year	Imports (tons)	Exports (tons)	Exports/imports, %
1994	419960	6916	1.65
1995	272069	4493	1.65
1996	315474	7833	2.48
1997	349330	8976	2.57
1998	317349	6177	1.95
1999	365308	5525	1.51
2000	417093	9051	2.17
2001	470004	5901	1.26
2002	488130	6175	1.27
2003	522852	10239	1.96
2004	608801	11313	1.86
CAGR, %	3.78	5.05	-

Source: Author's estimates based on data from SAGARPA (2004); SAGARPA (2005).

2.7 Economic results of the Mexican dairy sector after NAFTA, 1994-2004

Modernisation of the MDS in the context of an open market has been a difficult process and increased competition from NFDM and dairy products has further challenged domestic producers. However, growth in milk production (CAGR of 3.04%) was higher than the growth of GDP (CAGR of 2.67%), but growth in dairy production has been similar (CAGR of 2.62%) to the GDP, in the same period.

[80] This is supported by the fact that income elasticity for Mexican dairy products is as high as meat and fish and much higher than for US dairy products. Data from USDA Price elasticity for food products. http://www.ers.usda.gov/data/InternationalFoodDemand/StandardReports/Priceelasticitysubgroup.xls (May 15, 2005)

a) Milk and dairy production

The rate of growth in milk production by climatic regions shows that arid and semi-arid regions have grown more rapidly than temperate and tropical regions. Rates of growth for dairy herds show similar results (see Table 2.9).

Table 2.9 Growth rates of Mexican milk production and dairy herds by climatic regions, 1994-2004

	Share of milk production, %		**CAGR of milk production, %**
Regions	1994	2004	1994-2004
Arid and semi-arid	32.85	36.25	4.06
Temperate	49.96	40.08	2.60
Tropical	17.19	15.85	2.21
Total of the country			3.04
	Share of dairy herds, %		**CAGR of dairy herds, %**
Regions	1994	2004	1994-2004
Arid and semi-arid	38.68	43.68	4.47
Temperate	44.01	46.82	3.84
Tropical	17.31	9.50	-2.81
Total of the country			3.20

Source: Author's elaboration of data from SAGARPA (2004); SAGARPA (2005).

It should be noted that the government forecast that milk production would increase the most in tropical regions due to their endowment of natural resources (i.e. large grazing areas, 28% of the total land area and 70% of the available water in the country) (Dávalo Flores 1997; del Valle Rivera 2000). However, these expectations have not been fulfilled and milk production in tropical regions is not keeping pace with growth in the other regions. It is possible that a different technological trajectory is emerging or that milk production will continue to be a by-product of beef production (see Tabasco case, section 5.3 in Chapter 5).

In terms of dairy production, UHT milk, yogurt, butyric fat, cream and some types of cheese (e.g. Oaxaca and Panela) have shown faster growth than other dairy products (see Table 2.10). Behind this growth is the increasing popularity and acceptance of long shelf-life milk, UHT milk, cream and cheese for cooking and especially yogurt, which is becoming a stand-alone food and is linked to improving the nutrition and eating habits of both adults and children (Euromonitor 2005).

Table 2.10 Growth rates of Mexican dairy production, 1994-2004

Milk and dairy products	CAGR of dairy production, %
Pasteurised	-0.12
UHT milk	7.10
Re-hydrated milk	0.31
Total fluid milk	*1.80*
Powdered milk	0.30
Baby formulas	4.81
Total powder milk	*1.25*
Butyric fat	8.63
Fresh cream	10.20
Butter	2.97
Yogurt	13.73
Natural yogurt	13.16
Fruit yogurt	11.94
Total yogurt	*12.40*
Yellow or American cheese	3.22
Chihuahua	-0.45
Double cream	3.53
Fresh	-0.55
Manchego type	-5.68
Oaxaca	5.57
Panela	5.75
Total cheese	*1.29*
Total dairy production	*2.62*

Source: Author's estimations of data from SIAP (1999); SIAP (2006).

b) Dairy trade balance

The trade balance shows that total dairy exports have grown faster than imports (i.e. 5.05% vs. 3.78%) (see Table 2.11). Nevertheless, the volume of exports is very low, less than 3% of the imports (see Table 2.8).

Table 2.11 Growth rates of Mexican dairy imports and exports, 1994-2004

Dairy products	Imports CAGR %	Exports CAGR, %
Fresh milk	-2.51	-7.75
Cream	3.97	115.94
Non fat dry milk, NFDM	-0.09	-13.72
Evaporated and condensed milk	33.88	28.07
Yogurt	-14.63	66.25
Milk whey	0.05	23.58
Butter and other butyric fats	4.02	99.71
Cheeses	7.69	58.68
Milk preparations *(1)*	24.71	14.21
Total	3.78	5.05

(1) Milk preparations are powdered preparations with variable content, between 10% to 50% of dairy solids (e.g. NFDM, milk whey, casein, etc.), which may also include non-milk carbohydrates and food additives.
Source: Author's estimate based on data from SAGARPA (2004); SAGARPA (2005).

It should be noted that imports of milk preparations are growing faster than imports of NFDM (24.71%). Milk preparations are increasingly being used by dairy processors to substitute milk solids to produce ‘cheap dairy products’ (e.g. cheese and milk-like drinks) aimed at low-income groups (Losada, Bennett et al. 2001). It is argued that this has discouraged dairy farmers from increasing their production, since the prices of these milk preparations, i.e. substitutes for liquid fresh milk, are lower than the price of fresh milk (Cevallos Urueta 2005). There are no standards for testing the quality of these products either when imported or in use. This could be damaging for consumers, because either the ingredients are unacceptable or the labelling is misleading. On the other hand, dairy processors argue that the use of milk solids (e.g. milk preparations, whey proteins and caseinates) is specified on the label, thus ‘leche’, (milk) on the label is legitimate[81] (PROFECO 2005). Moreover, if retailers increase their imports of dairy products, this could affect the dairy processors[82] as well as the dairy farmers, who might not have sufficient incentive to invest in modernisation. The consequence would be even more small dairy firms and farmers going out of business leading to disinvestment in the sector and increased rural unemployment, as argued by several scholars (Martínez Borrego and Salas Quintanal 2002; Alvarez Macías 2005; Cervantes Escoto 2005; del Valle Rivera 2005; Rodríguez Gómez 2005; Salas Quintanal 2005). It is important to consider, however, that availability of ‘cheap dairy products’ might benefit the low-income population (the case of LICONSA) even if they are the result of foreign subsidised milk production. Furthermore, if the subsidies to dairy farmers (via Alianza para el Campo) disappear, it could be that the families dependent on this money will suffer. Therefore, the consequences of dismantling foreign and national subsidies in production systems require careful consideration (Stiglitz 2002; Beitel 2005; Stiglitz 2006), a subject that is beyond of the scope of this thesis.

c) Dairy production, consumption and trade

In summary, in the period 1994-2004, milk production grew faster (3.04%) than the annual growth of the population (i.e. 1.79%) (see Table 2.12) and the GDP of Mexico

[81] In PROFECO’s report it is argued that there is no problem with the protein content of these products since this is specified on the label. The problem lies in the use of the name ‘leche’, which is misleading for consumers.

[82] It is also the case that some large dairy processors have imported UHT milk and dairy products under their own brands or under the brand of their foreign suppliers. They commercialise these products using their own well-established distribution channels.

(2.67%). However, there was still a deficit in the system, which was covered by imported NFDM and dairy products. Imports of NFDM and dairy products increased to a rate of 4.91% per year in the same period (see Table 2.11).

Most imported NFDM (approximately 75%) is re-hydrated and homogenised with vegetable fat and distributed by the government via social programmes throughout LICONSA (Marín López 1997; Hernández Laos and del Valle Rivera 2000; SAGARPA 2000). Although there is great emphasis on social programmes, and per capita consumption has increased at the rate of 1.60%, it is still 40% lower than the Food and Agriculture Organization (FAO) recommends.[83] This might suggest that consumption has not increased, due, among other things, to the loss of purchasing power especially in the low-income population.

Table 2.12 Mexican total milk production, trade and consumption 1994-2004

Year	National production 000' millions of litres	Equivalent of imports 000' millions of litres[1]	Equivalent of exports 000' millions of litres[1]	Estimated National Consumption 000' millions of litres	National production %	Imports %	Population 000' of inhabitants	Litres per capita per year
1994	7,320.2	1,566.5	62.0	8,824.7	83.0	17.8	89,066	99.1
1995	7,398.6	1,464.9	35.7	8,827.9	83.4	16.6	95,104	92.8
1996	7,586.4	1,772.1	22.3	9,285.3	81.5	18.5	96,537	96.2
1997	7,848.1	1,936.5	42.2	9,742.4	80.1	19.9	97,920	99.5
1998	8,315.7	1,704.2	20.1	9,999.8	83.0	17.0	99,266	100.7
1999	8,877.3	1,921.5	10.3	10,788.5	82.2	17.8	100,569	107.3
2000	9,311.4	2,090.0	14.4	11,387.8	81.6	18.4	101,826	111.8
2001	9,472.3	2,582.5	20.1	12,034.6	78.5	21.5	103,040	116.8
2002	9,658.3	2,468.9	18.8	12,108.3	79.6	20.4	104,214	116.2
2003	9,784.4	2,509.9	39.6	12,254.6	79.5	20.5	105,350	116.3
2004	9,873.8	2,532.0	34.1	12,371.7	79.5	20.5	106,452	116.2
CAGR 1994-2004	3.04%	4.91%		3.44%	-	-	1.79%	1.60%

[1] Estimated on standard bases from SAGARPA, which define the amount of NFDM required to produce 1 litre of milk, but does not include milk preparations.
Source: Author’s estimates based on data from SAGARPA (2000); SAGARPA (2005).

2.8 Mexican dairy industry vs. US dairy industry

Compared with the US[84] dairy sector, the MDS differs substantially. The US produces surplus milk, which is de-fatted, dehydrated (i.e. NFDM), and sold in the export market. US milk production is higher than Mexico’s, and is highly standardised with a great

[83] FAO recommended milk intake per person is 188 kg/year. Mexico achieved approximately 61% of the recommendation in 2004 (i.e. 116 litres/year). Developed countries, even though their milk intake has decreased, still consume more than Mexico (e.g. 329 litres/year in Holland, 254 litres/year in US and 210 litres/year in New Zealand) (SAGARPA 2000).
[84] The comparison is with the US because this country is one of Mexico’s main suppliers of NFDM and dairy products and the lead dairy producer in the NAFTA region.

diversity of dairy products. The US dairy industry has economies of scale in milk production and dairy processing, which are technologically more advanced than in the Mexican dairy industry and highly competitive in the international market. The US industry focuses on production of value added products (e.g. low fat content and pro-biotic products) (Millman 1999; del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000; SAGARPA 2000). Mexican dairy firms produce milk and dairy products, which mainly target a growing national market, which nevertheless is considered mature based on its production and consumption patterns (Dobson and Proctor 2002; Dobson 2003).

US milk production has been subsidised by government, which has made business conditions more favourable (Marín López 1997; Marín López 1999; Hernández Laos and del Valle Rivera 2000; Tipping 2003); these subsidies have been criticised for the resulting overproduction of NFDM [85] (Beitel 2005). In the year before NAFTA, Mexican milk production received less subsidy than US production (Marín López 1997; Marín López 1999),[86] and there was inconsistency in the application of Mexican subsidies for milk production (Marín López 1997),[87] which still persist in public support programmes. However, it is clear that Mexican milk and dairy production is growing faster than in the US and EU systems. However, its growth is uneven. In Chapter 5, we will explain how the uneven development of capabilities in dairy regions contributes to this uneven growth.

2.9 Summary

This chapter introduced the topic of this research, the MDS, in terms of the general changes that have occurred in the period of analysis, which has been affected by a persistent economic crisis and the socio economic and political context (Appendix I).

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[85] US and EU farm subsidy policies have been further challenged by opposing groups, which argue that eliminating subsidies will not help the small and medium sized farmers, who depend on subsidies to survive. Cutting those subsidies could accelerate the consolidation of large farms (Beitel 2005).

[86] Marín López (1999) p 179-180 showed that EU and US exporters were selling NFDM at dumping prices. Nevertheless, no sanctions were applied to exporters to compensate farmers.

[87] Marín López (1997) p 261 showed that there are no comparable data on the differences in the subsidies for NFDM in Mexico and the US. However, it is clear that US subsidies have consistently protected US farmers' incomes (giving them higher prices) and subsidised consumers, whereas Mexican policy has been inconsistent, in some periods protecting consumers and in others benefiting producers.

Globalisation of the milk and dairy production obliged Mexico and other countries to change their protectionist policies and to adopt the neo liberal economic model, arguing that markets would create incentives for producers to invest without the intervention of governments, but this has not consistently happened. Furthermore, the neo liberal model seems to work under specific conditions established by governments in some countries but affecting others (e.g. high subsidies for milk and dairy production in the US). However, globalisation of the NFDM and other dairy products in the international market has increased competition in the global dairy market and the MDS has responded, but adaptations, adjustments and problems have been emerged.

The extents of changes induced by NAFTA are sufficient to differentiate the post-NAFTA period from the phase of modernisation, which started with the introduction of the Holstein model, which began in the 1950s. The MDS has a long history of gradual evolution towards specialisation in milk production. This has led to great variability in the use of technologies for milk production, i.e. a complex structure for milk production (i.e. a few specialised large farms and numerous small semi-specialised, family farms and dual-purpose systems), and great variability in productivity and competitiveness among and within regions, and compared to the US. While milk production has increased in Mexico’s arid, semi-arid and temperate regions, there is little evidence that Mexico is approaching self-sufficiency in milk production and there is significant concern about the economic sustainability of the MDS as a whole.

Mexican milk production is forecast to increase at a moderate rate, but not enough to satisfy increasing domestic demand. Nevertheless, its dairy firms has been producing increasingly more and better products because of improvements in the supply of high quality chilled milk, which has been achieved by the increasing integration of dairy farmers led by the large and MNC dairy processors using specific strategies imposing specialised milk production technologies and milk purchasing schemes.

The modernisation post-NAFTA of dairy processing shows that a few large and medium sized dairy processors coexist with MNCs and small producers of artisan cheeses, cream and butter (i.e. cremerías and queserías). Large and medium sized firms and MNCs produce high quality and varied pasteurised milk and dairy products for the national market. Small firms produce mainly artisan cheeses and dairy products for regional and local markets. This is discussed further in Chapter 5 for the cases.

These changes in the MDS may have increased the profitability of the system. However, some important factors define the competitiveness of the MDS. To understand these factors, which influence the integration and interrelationships among dairy farmers and dairy processors, Chapter 3 builds an understanding of the main factors that have to be addressed for capabilities development in regions and guides the literature review to build up a concept and analytical framework for analysing regional capabilities. Chapter 4 develops the concept and an analytical framework to systematically compare the relationships between the structure of the Mexican dairy regions, the capabilities development processes (bottom-up analysis) and the economic results, taking account of the implications of the top-down policy implementation, which has affected the evolution of the dairy regions.

Chapter 3. Reviewing the literature: Theoretical elements needed to identify and analyse the development of regional capabilities

Chapter 2 introduced the political and economic context of the MDS, in order to frame the main research questions from Chapter 1 (Section 1.2). Among the issues identified were that firms are heterogeneous with respect to their technologies, which are associated with the climatic conditions of the regions, and the ways of doing their business in specific regions. During the long period of the ISI, these firms evolved capabilities with the help of other national and regional actors. In this chapter, we draw from the extensive literature on evolutionary economics and innovation systems the theoretical approaches that will guide this research and help to identify and analyse the regional capabilities in agribusiness in a developing country. As previously noted and discussed further in this chapter, there is a scarcity of literature analysing agribusiness and the existing literature has gaps and shortcomings in proposing a way for analysing regional capabilities evolution in a developing country context.

To position the literature discussion, we begin by discussing the empirical issues to be taken into account (section 3.1) when selecting the literature. The selected theoretical approaches that are relevant in building up a concept and analytical framework to answer the research questions posed by this thesis are discussed in the following sections, namely, the regional system of innovation and regional capabilities (section 3.2), sectoral innovation systems (section 3.3), dynamic capabilities (section 3.4) and a function-based approach (section 3.5). In section 3.6, we summarise the approaches, seeking to develop a concept and analytical framework to be used in this research.

3.1 Empirical issues for the selection of the literature

As explained in Chapter 2, the MDS is a complex sector in terms of actors, processes, technologies and institutions, which is in the process of adapting to new international trade rules. Therefore, when searching for literature relevant for analysing capabilities development in dairy regions, we have to take into account the following peculiarities of the MDS and its specific structural conditions.

The technological and organisational processes that define progress in the dairy regions are an extent of the effective integration of dairy farmers and dairy processors. Dairy farmers produce the milk which is the main input for dairy firms. The progress of a dairy region is primarily through improvements in the integration of dairy farmers into the value chains of dairy industrialisation because of the need to control input qualities in order to efficiently produce higher quality dairy products, requiring the delivery of high quality chilled milk. A primary underpinning hypothesis of this research is that the coevolution of capabilities of these two groups of firms, which enhances value chain integration, is of primary importance in explaining the overall economic performance improvement of a dairy region. The more effective the integration of the value chain, the greater the accumulation of capabilities that is required. Integration is necessary because 'control of inputs' is a pre-requisite to 'more effective' (efficient) production, higher quality, and greater diversity of processed dairy outputs. For these outputs, fresh milk must be considered because in a modern retail context, safe and reliable long shelf life dairy products are of the utmost importance.

Differences in milk production systems. Dairy farms constitute a large number of firms (approximately 60,000, by 2004) with different scales and milk production systems. As already noted, the technologies in use, extent of owners' capital and climatic conditions vary across farmers and regions. At a national level, around 10% of farmers employ specialised milk production systems and most of these appear to be medium and large firms; the other 90 % are less specialised, a category that includes a huge range of semi-specialised and dual-purpose milk production systems and appears to be comprised mostly of small family farms (see Table 2.5) with limited capital and other resources. The MDS is therefore a collection of milk production systems with different configurations of technological components (see Table 2.3) and possibly different capabilities.

Capabilities development in dairy farms is of a localised nature as far as knowledge production and learning are concerned for several reasons. There is low mobility of production factors (e.g. land and labour for family production systems) and the nature of production systems is affected by climate conditions and natural endowments of the regions as well as the social and economic conditions of farmers. The combination of these factors affects the intensity of adoption of specific assemblages of technologies and artefacts specific to the sector and integration of the value chain for milk commercialisation, which is mainly a local process,[88] especially for small farmers. The effective performance of the dairy farmer depends on understanding the specificities of milk production components associated with the specific breeds of cows employed, a choice which is related to availability of land, crops, feedstock and other resources. Therefore, specific knowledge is required to depart from existing experience to innovate. For instance, alfalfa and grains are the main crops for intensive systems using milk-specialised cows. In the case of less specialised systems, grazing and, recently, intensive grazing systems are the most important sources of feedstock.

The localised nature of capabilities development is also influenced by two ‘core trends’ in the MDS. First, the specialised Holstein model has proved to be the most effective for improving farm productivity and the quality of milk (see section 2.4.2) under certain climatic and economic conditions and this has created a bias in the processes of capabilities building. In the current conditions of development of the MDS, most small farmers are struggling to update their milk production systems to implement adaptations of this specialised model. However, this system model may not be the most effective for all farmers.

Finally, integration of the value chain has favoured large and medium-sized dairy farms. These farms can produce high quality chilled milk in large volumes and thus operate at a profit in large scale or mass production systems. Nonetheless, maintaining a diversity in farm size by finding ways to support smaller farms has two important consequences: one to improve the total supply of good quality milk and the other to maintain farm income in order to prevent (further) migration to urban areas.[89] This may require policies involving public and private efforts.

Regarding specific structural conditions that influence the potential for capabilities development, the most important of these are summarised in the following paragraphs:

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[88] It is also true that large volumes of chilled milk can be commercialised between regions in large chilled tanks. However, these possibilities for regional trans-shipment primarily involve large farmers.

[89] In wealthier countries, maintaining farm income is an important reason for subsidies. In the Mexican context, a farm income-oriented subsidy programme would be a prohibitively expensive fiscal policy. This is one of the several underlying asymmetries influencing US-Mexican agricultural policies.

Localised character of knowledge vs. sources of knowledge supply. Despite the localised character of the capabilities building process already addressed in the literature of firm capabilities (e.g. Eisenhardt and Martin 2000), some of the sources of knowledge and technologies come from global suppliers of components of the technological systems, which are sold to large numbers of farmers (e.g. semen, mechanical and automatic milking machines, etc.). This makes dairy farming, at least for these components, a supplier-dominated sector (Pavitt 1984). Most of these technological components are available in the individual regions of Mexico through the actions of suppliers and consultants. However, the 'uptake' of these technological components for many farms, which might make higher productivity possible, is limited by shortcomings in farmers' absorptive capacity[90] (Cohen and Levinthal 1989) due to persistence in their current practices and business routines as well as limitations in their economic resources. To realise the potential for productivity improvements requires other organisations or intermediaries to augment farmers' absorptive capacities by providing them with knowledge through technology transfer and training programmes and, in some cases, by supplementing the economic resources they may employ to upgrade their technologies.

With respect to technology transfer and training programmes, agricultural extension services from public and private organisations can be a vitally important source of development for agribusiness as they were in the developed world.[91] This research indicates that such programmes are still crucial for developing countries and this is a principal motive for examining their specific role in capabilities building (see DEPAI, GGAVATT groups and DCyREMA training programmes). This is not a unique problem, as there is often a disconnection between financial and technological assistance, creating

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[90] Absorptive capacity refers to the knowledge that firms obtain through their R&D, which enables them to identify important new ideas or innovations, to exploit them for their own benefit, and to learn from the experience of others (Cohen and Levinthal 1989).

[91] Agriculture extension services started in the middle of the 19th century in Ireland. Between 1845 and 1851 the Irish potato crop was destroyed by fungal diseases and a severe famine occurred. The British Government arranged for "practical instructors" to travel to rural areas and teach small farmers how to cultivate alternative crops. This scheme attracted the attention of government officials in Germany, who organized their own system of travelling instructors. By the end of the 19th century, the idea had spread to Denmark, the Netherlands, Italy and France. In the United States, the Hatch Act of 1887 established a system of agricultural experimental stations in conjunction with each state's land-grant university. Later on, the Smith-Lever Act of 1914 created a system of cooperative extension to be operated by those universities in order to inform people about current developments in agriculture, home economics, and related subjects.
Agricultural extension: http://en.wikipedia.org/wiki/Agricultural_extension (Retrieved on 21/04/10).

a mismatch between the demands of knowledge, technologies and resources and their supply.

In the case of dairy production, similar problems are present. A few medium and large firms account for the major share of chilled milk collected for dairy production.[92] Changes in capabilities in large and medium-sized dairy firms are sorted out as long as the interactions of the individuals within dairy firms are capable of producing new products and expanding their markets. These firms may well have the resources to develop capabilities for coordinating R&D, marketing, production, operations and financial processes for the negotiation of the changes. However, this is not the case for small artisan cheese producers (many of whom are dairy farmers), who neither have the resources nor the absorptive capacity to advance. They utilise the leftover chilled and non-chilled milk for dairy production. For this group of firms, there have been fewer efforts at a regional level than for dairy farms and much less at the higher Federal government levels. In all dairy production activities, however, there is a very important interdependence between the upgrading of dairy farmer production to chilled-milk methods and advances in industrial dairy production.

In summary, in the case of agribusiness, we are seeking theories that explain how the capabilities of contrasting groups of firms (dairy farms and firms) operating in the same sector but in different regions changed, where integration is strongly influenced by the coevolution of capabilities along the value chain. Due to the characteristics of the type of knowledge that is created and exchanged among these firms (much of which is tacit), we need a theoretical framework that helps explain how these capability-building interactions between regional and national private and public actors have influenced dairy farmers to change their milk production practices and build up the infrastructure as explained in Chapter 2. In other words, the theoretical framework needs to consider institutional aspects governing the regions and how they might assist or retard the process of productivity improvement and growth. Finally, we also need theories from the existing literature that help us to understand how to improve policy making because the creation and exchange of knowledge is not free and the number of users is large

[92] There are no available data for the chilled milk catchment areas of these firms. However, there was an agreement among interviewees that Lala, Alpura, Nestlé, and Sigma Alimentos are the main collectors of chilled milk for industrialisation.

(small dairy farmers and artisan cheese makers). There need to be regional policies to address the overall performance of regions with differentiated features.

Having set up these considerations, we identified from the literature four main theoretical approaches to guide this research. The revision of these theoretical approaches has the objective of assembling theoretical bases which enable this research to pursue the aim of understanding how regional capabilities evolved in the MDS. As pointed out in the introduction, much of the literature about capabilities development and accumulation (i.e. dynamic capabilities) is based on firms as the main unit of analysis. This literature does provide insights about how capabilities evolve and lead firms to grow. However, the evidence available for explaining higher levels of aggregation of capabilities, e.g. regions and industries, is sparser. Regional innovation systems (RIS) and sectoral innovation systems (SIS) literature provide important additional elements and more useful levels of aggregation. RIS and SIS approaches complement each other in their attempt to explain how interactions between actors in a specific sector create learning processes (within organisations and among them), and how institutional set ups affect them. However, they do not explain further how these interactions occur and affect the changes of the capabilities at the level of individual firms in systems/regions in which they are located. Therefore, for policy recommendations using a more systematic way of analysing these interactions, a function-based approach is introduced. These reviews focus on extracting some elements to identify and analyse the capabilities evolution of regional firms affected by multiple organisations, i.e. regional capabilities.

In section 3.2, the contributions of the RIS literature are examined for ways of understanding how the structure and interactions of economic actors, firms, with other actors, organisations, in a specific location might produce local knowledge, learning and innovation, and how the associated regional and national policies might influence these interactions. This section has two subsections. Subsection 3.2.1 explains the implications of distance among actors and the specificities of the traded knowledge and resources in the regions (e.g., Gertler 2003; Asheim and Coenen 2005; Asheim and Gertler 2005) and the implications of top-down policies and context (e.g., Cooke 1998; Howells 1999; Cooke 2004a; Doloreux and Parto 2005; Iammarino 2005). Subsection 3.2.2 examines a regional capabilities approach that specifically proposes to explain the integration between micro- and meso-level capabilities in regional innovation systems for the regeneration and renewal of regions in high tech sectors in developed countries (Cooke 2005; Heidenreich 2005; von Tunzelmann 2009a) and a unique case in a developing context (Padilla Pérez 2006). Regional capabilities approach is central to the development of a concept and an analytical framework in this research.

In section 3.3 we examine the SIS approach (Malerba 2005) which complements to the RIS approach by considering the specificities of knowledge and technologies for the appropriability and cumulativeness of capabilities in a sector. Using this approach helps us to understand the integration of different groups of firms – which in agribusiness are also affected by climatic and regional endowments – and to understand the multiple sources of knowledge and technologies which exist for the specialised model of milk production and dairy production that coevolve in an incremental process for innovation.

Once we have reviewed the literature that focuses mainly at a meso level, but nevertheless looks at the micro level for regional capabilities building, section 3.4 examines some of the main approaches to study the micro level and firms' capabilities or dynamic capabilities concept (e.g. Leonard Barton 1995; Teece, Pisano et al. 1997; Helfat, Finkelstein et al. 2007). The dynamic capabilities concept explains some of the micro foundation processes, organisational routines taken up by the proponents of regional capabilities approach (Cooke 2005; von Tunzelmann 2009a). This section seeks to explain how routines or organisational routines evolve towards improved or new capabilities within firms and more generally in organisations (e.g., Dosi, Nelson et al. 2000; Zollo and Winter 2002; Winter 2003), when individuals in firms interact among themselves and with other individuals outside their organisations. This thesis argues that these interactions eventually influence changes of capabilities of larger systems/regions. The analysis focuses on the understanding of intra-firm learning and inter-organisation learning mechanisms (e.g., Lundvall, Johnson et al. 2002; Zollo and Winter 2002; von Tunzelmann 2009a).

The foundation hypothesis employed throughout this research is that the evolution of regional capabilities requires the co-evolving processes of intra- and inter-firm and organisation interactions, which involve intra- and inter-organisational learning. These interactions modify the routines deployed by firms, which eventually change into improved and/or new firms' capabilities. Although this research did not involve direct observation of these specific individual interactions, an understanding of their contribution to changes in specific technological components and processes within the system informs observations at a more aggregate unit of analysis, i.e. the region, which is the focus of this research. By examining and comparing micro-meso levels of the three regions chosen for this study, it is possible to understand how the evolution of regional capabilities has influenced their economic performance.

In section 3.5, in order to analyse and compare regional capabilities systematically in the three regions with the aim of improving policy making to support economic growth of the regions, a function-based approach, another strand of the literature of innovation system literature is sought (e.g., Bergek, Jacobsson et al. 2005; Chaminade and Edquist 2005; Edquist 2005; Bergek, Jacobsson et al. 2008).

Section 3.6 summarises the chapter, which establishes the theoretical bases for the definition of sector-specific regional capabilities and an analytical framework to analyse capabilities in regions. Chapter 4 will develop them.

3.2 Regional innovation system (RIS) and regional capabilities approaches

Most of the theories related to the growth of firms (evolutionary economics and resources-based view) explain in one way or another that there are micro-foundation processes (which can be called routines and capabilities) embedded in the practices of firms, which together with other firm assets (e.g. individuals' skills, artefacts and economic resources) must evolve for firms to grow. Therefore, it is necessary for a firm to resolve in a coherent way the problem of conflicting sources of information and knowledge to create new knowledge internally or to take it from everywhere else regarding the improvement of its processes/products/services. Eventually, resolving such problems may make it possible for the firm to become more innovative and, depending upon the nature of markets and competition, may lead to growth and improved competitiveness. From this perspective, the distances and interactions that are most important for improving firm performance are between individuals within firms (i.e. intra organisational) who are struggling with the problems of resolving disagreements and determining what really will be an improvement (i.e. the output) and how to reach it, since all improvements have costs as well as benefits.

On the other hand, the regional innovation system approach extends this basic explanation by recognising that these interactions, relationships and/or collective processes among firms and other actors in a region, together with other complementarities of the region (e.g. infrastructure, availability of human capital, knowledge, institutions and resources) assist firms to grow and/or to become more competitive. From this perspective, the most important interactions and relationships are the coherent ones aligned among firms and organisations (i.e. inter organisational). However, in most countries, regions are not self-governed, although local and regional institutions are present and more important, regions have their own socioeconomic and cultural properties. Moreover, national and possibly international institutions also influence them. The contrasting emphasis placed on intra-firm interactions and on interactions between firms and other actors, inter-organisations interactions, makes it clear that there is a need to integrate our understanding of the evolution of changes in firms with an understanding of the evolution of a meso level (or regions) to understand the process of economic growth.

The study of RIS addresses the space between national institutional set-up, which often does not translate well to explain adequately the processes and interactions among actors in specific regions. The premise of RIS studies is that regional actors improve their relative performance by developing effective interactions supporting learning and innovation, which in turn fosters the competitiveness of firms located in a specific region. However, the RIS literature does not study the micro-level processes of individual firms, processes that section 3.4 examines. Complementary to the RIS approach, the regional capabilities approach theorises and explores how to integrate the micro and meso levels for capabilities evolution.

The aim of investigating the RIS literature is to identify the factors which explain why some regions adapt and generate certain forms of knowledge and learning more successfully than others. The claim of the RIS literature is that better performance is not simply the result of chance, i.e. the co-location of successful firms. It may be the result of improved speed of creation and exchange of tacit and codified knowledge that leads to the coevolution of capabilities of economic actors and other organisations in a region (von Tunzelmann 2009a).

In this section we will select a few key ideas relevant among the numerous frameworks in the RIS literature to understanding the main factors that affect the integrations of micro and meso regional levels for capabilities building in subsection 3.2.1, and the regional capabilities approach is discussed in subsection 3.2.2 .

3.2.1 Regional innovation system approach

RIS approach research has grown exponentially since the 1990s, paralleling the rapid growth of the national systems of innovation literature (Cooke 1998; Asheim and Gertler 2005; Cooke 2005; Doloreux and Parto 2005) and replacing regional development models, which sought to explain the emergence of successful clusters of firms and industries in many regions in the developed world. For instance, the idea of industrial clusters grows out of Marshall's theory. It was followed by further discussion of the geography of innovation to understand competitiveness and production (Audretsch and Feldman 1996), the development of local clusters in a global economy (Porter 2000) and the importance of institutions and their role in the economic geography of tacit knowledge (Gertler 2001; Gertler 2003).

In seeking to understand the geography of innovation, 'RIS can be thought of as the institutional infrastructure supporting innovation within the production structure of a region' (Asheim and Gertler 2005, p 299). This concept highlights an important level of governance of economic processes between the national level and the cluster or firm. Thus, regions are bases of economic coordination at the meso level to various degrees of both private and public representative organisations, which promote enterprise and innovative support.

One interesting definition is that an 'RIS is one that comprises a "production structure" embedded in an "institutional structure" in which firms and other organisations are systematically engaged in interactive learning' (Doloreux and Parto, 2005, p 143, citing Asheim and Isaksen 1997; Cooke, Gómez Uranga et al. 1997). This definition captures the complexity of the RIS without revealing what constitutes the production and institutional structures, the actors, and the interactions and inter-relations that bind them together. If coordination and institutions are the mechanisms that support the interactions of economic actors and multiple organisations in a localised space, i.e. a region, for innovation, then interactions among multiple actors and the processes of coordination and institutions are central to sustaining economic growth of regions.

Studies in the RIS tradition share a number of important assumptions aimed at explaining the uneven geography of innovation over time (Asheim and Gertler 2005; Doloreux and Parto 2005). They are: 1) Location matters – the proximity of actors plays an important role in generating and transferring knowledge (i.e. user-producer interactions) as well as mediating local-global knowledge flows; 2) Localised governance and institutions are important to understanding innovation; and 3) National and regional institutions influence learning processes.

Location matters when we try to understand the nature of knowledge that is being created and exchanged (i.e. tacit and codified, synthetic and/or analytical knowledge) (Asheim and Gertler 2005; Asheim and Coenen 2006). If competitiveness depends on the success of producing improved or new products and services, tacit knowledge constitutes one of the most important bases for value creation (Pavitt 2002). Regions can also function as collectors and repositories of knowledge and ideas, and provide environment or infrastructure which facilitates the flow of knowledge and learning (Florida 1995). This perspective reflected disillusionment with more optimistic models of technology transfer and the neoclassical economic theory of 'perfect information', which assumed universal or nearly universal distribution of knowledge.

Proximity and spatial concentration of actors play important roles in generating and transferring knowledge (i.e. user-producer interactions). These factors can promote cooperative innovation activities between firms and knowledge-creating and diffusing organisations, such as universities, training organisations, R&D institutes, technology transfer agencies, etc., and the innovation-supportive culture that enables both firms and systems to evolve over time, under prevailing sets of rules, conventions and norms through which the process of knowledge creation and dissemination occurs (Doloreux and Parto 2005). However, globalisation of markets and foreign direct investment (FDI) can substitute for the advantages of proximity in firms' efforts to keep updated (Padilla Pérez 2006).

Localised governance and institutions in the RIS are important to understand innovation. From this perspective, regions may be defined as 'territories smaller than their state possessing significant governance capacity and cohesiveness differentiating them from their state and other regions' (Cooke, Gómez Uranga et al. 1997, p 480). A region is a territory and/or a jurisdiction that is geographically defined, administratively supported by arrangements of social networks and institutions that interact with proximately located firms on a regular basis (Cooke 2001). This definition includes the cultural aspects of the region. Therefore, regions seem to be 'homogeneous' in terms of a particular kind of association or related characteristics, and have a degree of internal cohesion. This cohesion is provided by the institutional context that underlines the interconnectedness and interdependency of the actors within the region (Doloreux and Parto 2005).

A number of RIS studies share these premises. First, it is often recognised that the regional context provides a set of rules, conventions, and norms that prescribe behavioural roles and shape expectations (Johnson 1992). Second, an RIS involves a complex network based on informal social relationships in a limited area, which determines and/or erodes innovation capability. Regions become the substratum in which the long-term collective learning processes are embedded (Camagni 2002) .These collective learning processes are especially important in lagging regions when they are forced to improve productivity and to become competitive (Camagni 1992). Third, the strength of local learning systems depends on the arrangements of the intangible socio-cultural and political assets that define the internal dynamics of the region. These intangible assets, together with trust, help to overcome market failures and reduce transaction costs by supporting stable and reciprocal exchange among the actors in the region (Doloreux and Parto 2005). Fourth, an RIS involves important linkages between firms and various regional organisations and institutions that are related to the innovation process, such as universities, technology transfer organisations and industry associations (Cooke 1998). These premises provide a framework for understanding how regional interactions or networks and institutions operate the mechanisms of knowledge generation and transfer (i.e. learning processes) that influence the creation of capabilities and improve the competitiveness of the region (Cooke 1998; Cooke 2001). This is consistent with Porter's more general observation that firms competing in the same industry or collaborating across related industries, tend to trigger learning, innovation and eventually competitiveness[93] (Porter 1998).

Although the RIS concept has been widely employed, RIS is not a clear concept nor one that is readily operational (Doloreux and Parto 2005, p 143). Moreover, questions have been raised about whether the 'region' referred to by RIS approaches can actually be well defined. According to Bathelt (2003), not all regions can automatically be considered as innovation systems, although RIS are sometimes, viewed as being the norm. He argues that one of the core problems of the RIS approach is that it implies that a region is an entity, which hosts a large part of an economic value chain and has a governance structure of its own, independent from its environment. However, such regions are hard to find even in countries with a decentralized governance structure; regions lack major political decision-making competencies, independent institutions and politico-administrative autonomy. Furthermore, only a few regions can be characterised as being economically self-sufficient. Even if autonomous economic entities and strong institutional set-ups exist, the territorial dimensions of both types of governance (national and regional) can differ substantially. Therefore, it seems unrealistic to treat regions as largely homogeneous in terms of their industry-culture mix from which a single innovation system could arise. Bathelt further argues that the empirical work of RIS has largely focused on exceptionally successful innovation clusters, while neglecting the majority of 'normal regions'. He concludes that the RIS concept should be applied carefully (Bathelt 2003, p 670).

From this discussion, it is clear that territorial agglomerations have an important role when it comes to regional embedding of tacit knowledge and learning processes and the institutions affecting their success. However, these once successful regions can also run into serious problems when the pattern of interaction leads to path dependency and

[93] Industries can be further concentrated within a region or might span political and other boundaries constituting a unit of analysis sometimes called a 'cluster'. This term, however, will not be used in this thesis because the natural resource base of dairy firms is necessarily geographically dispersed due to the intensity with which land is used to produce the principal input (milk) and dairy firms themselves are somewhat geographically dispersed because of the costs of fluid milk transport. Both mechanisms of geographic dispersal make it difficult to conclude what might define a 'cluster' as the term is used with respect to manufacturing activities.

negative 'lock-in' tendencies, e.g. when a dominating technological trajectory is not modified or changed in the face of change leading to the industry being outcompeted due to lack of innovation (Asheim and Coenen 2005).

Despite criticisms of the RIS concept that focus on the amorphous qualities of defining 'region' and questioning the independence or autonomy of local/regional actors from larger national and international contexts, the RIS concept is worthy of further empirical exploration as a possible bridge between micro, meso and macro levels of analysis. We argue that RIS approach identifies and attempts to deal with the 'intermediate space' between regional and national institutions and policies such as those that might be examined as part of a national innovation system analysis and the intra- and inter-firm processes of knowledge accumulation, which underlie resource-based and evolutionary approaches to firm performance. The intermediate space is comprised of several elements. First, it encompasses inter-firm interactions among firms that are proximate due to the lack of ready transportability of knowledge. Second, it includes interactions between firms and localised representations of central government, regional government, and other regional organisations (e.g. industrial associations, research organisations, etc.) in order to capture the often greater relevance of local interactions in knowledge accumulation and capability building. Third, it proposes that both these two elements are constituted and derived from persistent social interactions and networks that transcend specific organisational forms and from which many of these forms are derived.

In attempting to make the RIS operational for the purposes of the present research, the literature suggests a number of relevant issues for investigating interactions and ill-defined boundaries of the regions, each of which poses specific questions that will make it possible to draw up conclusions about the nature and extent of regional influence in capabilities building. These relevant issues are summarised below.

Interactions and relationships among regional actors are relevant issues for understanding the creation and flows of knowledge, i.e. they define the learning regions (Cooke 2004a), which support the growth and knowledge accumulation of actors. Interactions and relationships among regional actors focus attention on the local trade of tacit knowledge, if we assume that other ways of knowledge are relatively available (explicit/codified knowledge) for everyone (Gertler 2003). Thus, 'the creation of unique capabilities and products depends on the production and use of tacit knowledge' (Gertler 2003, p 79, quoting Maskell and Malmberg, 1999, p 172). From this perspective, tacit knowledge is a key determinant of innovation in regions as well as the mechanisms for creating it (Asheim and Gertler 2005). Asheim and Gertler (2005, p 293) argue that

> 'tacit knowledge does not 'travel' easily because its transmission is best shared through face-to-face interaction between partners who already share some basic commonalities: the same language; common 'codes' of communication and shared conventions and norms that have been fostered by a shared institutional environment; and personal knowledge of each other based on a past history of successful collaboration or informal interaction. These commonalities are said to serve the vital purpose of building trust between partners, which in turn facilitates the local flow of tacit (and codified) knowledge between partners'.

These are the bases for learning by interacting, which produce tacit knowledge simultaneously with the act of transmission, through user-producer interactions (Lundvall 1988) in two directions from producer to user and the other way around from user to producer (Gertler 2003). This thesis argues that these interactions are also the basis for knowledge creation and exchange processes achieved by intra and inter organisational learning. Whereas in the firm, these user-producer interactions are internal, in a region user-producer interactions are between firms and other actors. Thus, they should be observable and the range and extent of such interactions will help identify whether RIS-type processes are in operation. However, learning by interacting is not universally available, because what is being created and exchanged is tacit (and codified knowledge). This might follow specific learning curves, and it might require other complementary assets (von Tunzelmann 2009a). Hence, a critical examination of commonalities (and points of divergence) and the nature and extent of interactions (or their absence or ineffectiveness) have empirical implications in analysis of a RIS and its economic outcomes.

Structure of the region (co-location of actors) is a relevant issue for understanding the localised contribution of interactions and resources (both tangible and intangible) to capabilities development. Such a structural examination should include information about the concentration of firms, stocks of skilled labour, and the presence and activities of local organisations, universities, industrial associations, research centres, etc. This approach is shared not only by the RIS approach but also by efforts to understand clustering (Saxenian 1990). A supportive structure is one that creates a climate for actors' understanding of each other's intentions in order to create trust for sharing information and promoting tacit knowledge exchange (learning by interacting), which reduces transaction costs among the actors (Maskell 2001). Furthermore, in the case of firms competing in the same region, the fact that firms are co-located might improve incentives to exchange information/knowledge, benefiting the firms involved. By using a region's structure as a relevant issue, there is further opportunity to identify interactions and consider whether specific actors are excluded or marginalised in interactions because of their structural position, e.g. because they are small relative to rivals, which might be the case for small firms in any sector.

Amin (2000, p 14. Cited by Gertler, 2003, p 86-87) argues that rather than seeing 'the local as the only source of tacit knowledge for competitive advantage'... 'it is within organisational spaces, with their complex geography blending action at a distance and local practices, that codified and tacit knowledge are mobilised for competitive advantage'. He asks 'Is it not relational proximity – more specifically, ongoing organisational routines and the social practices of collectives implicated in a common venture – rather than geographical proximity that constitutes the 'soft' architecture of learning? Such relational proximity might, of course, draw on face-to-face contact, but it can also be achieved at a distance (isn't this what the communications revolution and global business travel are all about?). More importantly, relational proximity does not in any way implicate, a priori, local clustering or any of the other properties of place that economic geographers and geographical economists have come to stress in recent years'.

Thus *regional-national-global interactions* are relevant issues for assessing the relative importance of the RIS and the division of labour of the actors within a system/region/country (Cooke 2005). In some cases, there is a greater interdependence among actors for the production and diffusion of tacit/codified knowledge developing various forms of meso level interactions with the national level (Asheim and Isaksen 1997; Asheim and Coenen 2005; Asheim and Gertler 2005; Asheim and Coenen 2006). In other cases, regional-global networks create 'regional knowledge capabilities' with other clusters outside the regions, e.g. biotechnology (Cooke 2005). Other sources of knowledge could also be global intermediaries or consultants, suppliers of specific technologies or using communities of practice[94] among users (Wenger and Snyder 2000).

Interactions outside the region might be seen as contradicting the RIS approach focused on co-location as an influence on efficiency of the tacit knowledge trade. It is an empirical question as to whether synthetic knowledge (e.g. engineering-based industries mainly in mature industries for solving problems) or more analytical knowledge (e.g. science-based industries, such as IT and biotechnology) is relatively more important. For instance, analytical knowledge is particularly important in regional-global interactions for explaining outcomes of improved capabilities and accumulation and/or competitiveness (Asheim and Coenen 2005; Asheim and Gertler 2005; Cooke 2005; Asheim and Coenen 2006). Such an examination will naturally highlight formal technology transfer contracts from advanced country actors to less developed and developing countries' actors.

These considerations regarding knowledge exchange also involve the state of pre-existing knowledge, human capital and absorptive capacity to assimilate and use new knowledge at the local level (e.g. Padilla Pérez 2006). In the RIS approach, these factors are located not only within individual firms but also in other organisations supporting firms, therefore, more generally in the region. For example, there may be capable actors who are able to identify and put together different pieces of knowledge and to create new knowledge (some of which may have a tacit character). These processes are likely to be sector-specific and their analysis is part of the subject of the sectoral innovation system approach (SIS) in section 3.3.

Further elaboration on the debate concerning localisation argues that interactions of the RIS and NIS can be seen as relevant issues in two ways: top-down and bottom-up approaches. In the NIS framework, learning processes emerge from the mobility of production factors between geographical locations within a country (Lundvall 1992).

[94] Communities of practice are defined as groups of workers informally bound together by shared experience, expertise and commitment to a joint enterprise. They are self-organised for solving problems facing larger organisations, and in the process they might produce innovation (products and processes) (Wenger and Snyder 2000).

When the factors of production and innovation are less mobile, regions are more important (Cantwell and Iammarino 1998) for localised interactions, which provide dynamism to regions, i.e. bottom-up approach[95] (Cantwell and Iammarino 2003). This complements the traditional top-down approach [96] (Howell 1999). Therefore, geographical asymmetries in countries raise questions about to what extent top-down and bottom-up criteria can explain (even allowing for strong and weak RIS) the extent to which a particular successful RIS is distinctive (Cooke 2005). What is relevant is whether larger (national or international) institutions and policies affect regional activities, i.e. top-down approach (Howells 1999), regardless of the presence of regional differences[97].

A partial answer may be that in order to succeed, a RIS must have internal coherence, collective identity and conform to the 'rules of the game', all of which creates a distinct context, although difficult to observe at the meso-level (Cooke, Gómez Uranga et al. 1997). Iammarino (2005) alters the viewpoint to make the RIS a negotiated outcome involving coordination and hence the potential for coordination failure. However, if a normative interpretation is given to the RIS framework, then the challenge for policy making becomes what the bottom-up influence of the RIS might have for national public policy, including efforts to avoid inadequate support for solving regional problems (i.e. systemic failures resulting from lack of top-down and bottom-up coordination) (Howells 1999). Examination of coordination issues may reveal either weaknesses or lack of social capabilities (or institutions, following Nelson and Nelson 2002), which eventually restrain the capacity (and perhaps the capability) of the region from making the institutional changes required for growth.

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[95] Examples include: the localised communication, knowledge acquisition and learning patterns related to innovation processes (user-producer processes) at the individual and firm or group level, which might shape diffusion of new knowledge; localised patterns to reduce uncertainty during periods of economic crisis, localised network integration (within and between networks, intra- and extra-region) and consequent degree of alignment of governance modes; and historical path dependence of localised innovation processes (Cantwell and Iammarino 2003).

[96] Examples include: type and intensity of interactions between the business sector and the economic system; role of public sector and innovation policy; institutional framework, industrial structure and intensity of private and public R&D activities; extent of regional network externalities, scale and scope of geographical agglomerations; degree of openness, capacity to attract/absorb external resources, and integration in global innovation networks; and forces driven by the historical evolution of regional societies (Howell 1999).

[97] E.g. GATT and NAFTA influenced changes in the agriculture policy, from PROCAMPO to Alianza para el Campo; however, regional policy implementation varies according to regional actors' perceptions and institutions, see Chapter 5.

Furthermore, a lack of capabilities in the regions for generating and diffusing new knowledge and technologies or a lack of internal coherence or governance within a region may block the innovation process. Network governance ‘alignment’ arises when top-down and bottom-up elements agree over specific issues. In contrast, network governance ‘misalignment’ occurs when the same elements are in conflict or are searching for improvements in differing directions. Misalignment is a threat to the coherence and progress of a region. Consequently, it may be said that regional modes of governance, markets and hierarchies are intertwined through various levels of networking, and play an important role in systemic success and growth (Iammarino 2005, citing von Tunzelmann 2004) or failure of regions. Regions with misaligned or incoherent institutions and governance are highly dependent on the NIS and imported technologies for innovation. Their high dependency on external providers is usually coupled with a low level of openness to and attractiveness for external resources (Iammarino 2005).

The capacity of regions to survive and benefit from technological change and globalisation is strongly influenced by the region’s internal organisation and structure, which are subject to (micro-meso) changes over time (as learning processes are, by definition, not stable). This may lead to the strengthening or the breaking down of systemic coherence. In other words, network governance alignment does not only imply alignment of objectives (market/non-market, private/public institutional arrangements) and levels of decision-making (micro, meso, macro tuning of organisations); system integration increasingly also requires the alignment of old and new technologies (Iammarino 2005, citing von Tunzelmann 2003); which will be discussed later in subsection 3.2.2 on regional capabilities.

In summary, it is clear that proponents of an RIS approach have been trying to put forward a conceptual framework that aims to capture how economic development takes place within regions. RIS approach underlies the importance of actors’ interactions with regional and national institutions and possibly global organisations and institutions. These interactions create a knowledge infrastructure and transfer systems as basic conditions for firms in those regions to succeed as well as to promote systemic localised learning processes, bringing about the innovativeness and economic growth of regions (Asheim and Gertler 2005; Doloreux and Parto 2005). However, in order to achieve this, there is a need for regional network alignments (von Tunzelmann 2003; von Tunzelmann 2004; Iammarino 2005).

From the above discussion explaining the interactions and relationships that constitute the theoretical foundations for capabilities building, there is no consideration about how tacit knowledge is created and exchanged, which is fundamental for this research when integration of the value chain is due to local users and producers of knowledge. Furthermore, what has not been achieved is a proposition that leads to how RIS policies can upgrade the knowledge bases of firms in regions over time (Asheim and Gertler 2005). In other words, there are gaps in the understanding of how the concept can be operationalised for policymakers to improve regional economic performance. This is consistent with some of the criticisms of the RIS which include the following:

a) RIS analysts fail to consider how regions have been historically institutionalised as spaces of political-economic intervention and action (MacKinnon, Cumbers et al. 2002; Heidenreich 2005) ;
b) The RIS concept prevents further exploration of the interactions of regional actors with national and external networks and institutions (transnational and nation states); which might play a major role in innovation and its governance (MacKinnon, Cumbers et al. 2002);
c) The RIS provides only a static analysis of successful regions, failing to address adaptation, renewal and regeneration in terms of how regions can sustain growth in the face of rapid changes in technologies and markets, which may threaten the basis of such growth (MacKinnon, Cumbers et al. 2002; Asheim and Coenen 2005; Cooke 2005; Heidenreich 2005; Asheim and Coenen 2006; von Tunzelmann 2009a). Since adaptation, renewal and regeneration are essential to growth, the RIS approach does not even address how ‘successful regions’ re-invent themselves (MacKinnon, Cumbers et al. 2002, cited by Cooke, 2005, p 1132).

As a result, recommendations for innovation policies based upon an RIS analysis might be questionable (Doloreux and Parto 2005, p 134).

In this thesis, the proposal of a regional capabilities approach attempts to integrate micro and meso levels looking at the micro processes that evolve capabilities and tries to explain the dynamics and growth of the RIS in a historical context. The approach appears useful in filling the gaps critics have identified as well as providing a more direct means to operationalising the RIS as a policy-relevant concept.

3.2.2 Regional capabilities approach

The argument of the RIS is that the most appropriate scale at which to sustain innovation based on learning economies is the region (Cooke 1998). The empirical agenda supporting this conclusion is advanced by making comparisons between localised and non-localised learning and by examining different modes of integration between regions to provide evidence of the presence or absence of success of one region relative to others. It is also advanced by attempting to explain why some regions adapt and generate certain forms of knowledge more successfully than others. Ultimately, it aims at demonstrating that the ability of firms to connect to and fit into a RIS helps to explain their competitive advantage and that of the regional systems in which they are embedded (Doloreux and Parto 2005). Consistent with these objectives, the main lines of inquiry of the research in this thesis are to find out whether regions develop capabilities, what type of capabilities they develop and how they do so.

A central contribution to the theoretical understanding of regional capabilities for starting up, regeneration and renewal of regions is the proposal of von Tunzelmann (2009a), who theorises about regional capabilities analysis based upon an understanding of how integration of the micro and meso levels helps to explain catching up processes and industrial regeneration when traditional routines are replaced by sets of new ones. However, von Tunzelmann does not propose how to operationalise this approach.

Empirical cases in developed contexts propose different ways of approaching regional capabilities. For example, Cook (2005) argues that the previous top-down institutional-driven process of regional development may be transformed into a bottom-up and knowledge-driven process and contends that this process is responsible for the renewal of regions in the biotechnology sector. Heidenreich (2005) argues that changes in capabilities of cities (regions) facing economic restructure are central to their successful transition. In a developing context, regional technological capabilities have been analysed for electronic manufacturing, for which a foreign direct investment (FDI)-dominated sector (Padilla Pérez 2006) has played a specific role. In the following paragraphs, we analyse the main arguments of these authors as a way of guiding us to integrate the micro-meso level of capabilities building in agribusiness.

One of the problems in the analysis of regional capabilities and in general, capabilities is the lack of agreement in the concept (see also section 3.4). ‘As it is, there is at present a mass of confusion both theoretically and empirically about this clearly important set of concepts. It does not help that formal theoretical approaches such as that from economics largely avoid probing this whole area; in effect a new mode of analysis has to be developed to make much headway’ (von Tunzelmann 2009a, p 12). In explaining how to start up or revive innovative regional systems, von Tunzelmann (2009a, p 11) argues that capabilities are seen as necessary for success at every unit of analysis, from individual agents/firms/systems/regions/countries. He proposes that progress might be made to this end by studying how traditional routines are transformed with revolutionary new technologies, a process that requires examining how to integrate the micro-meso and even macro level of capabilities evolution (ibid p 17).

von Tunzelmann (2009a) argues that ‘...‘dynamic capabilities’ of firms represent the extent to which the changes in their own capabilities (in production) influence or are influenced by change in the capabilities of consumers and/or suppliers, in real time (p 16). The situation for the dynamic capabilities of regions is analogous….’ Then, ‘This clarification allows us to portray the regional innovation system capabilities’ (p 11). He claims that at a regional level, systems integration involves coordinating a diverse structure of ‘value networks’ in order to align diverse objectives of public and private actors, and that these integration processes are inherently limited by the ‘capabilities’ of other higher level actors to link their policy making to client needs. Therefore, capabilities are interactive and dynamic at a regional level.

The proposal of von Tunzelmann (2009a) for regional capabilities draws on Sen's work (1985) on consumer capabilities[98] and on a resource-based view (Penrose 1995) of firms or producers' capabilities (p 12). However, he focuses on producers' capabilities to explain regional capabilities. He notes that specific capabilities are 'core' or central to competitive advantage in the resource-based theory of the firm. In contrast, neoclassical theory does not address the problem of building competitive success – a firm is either competitive or is eliminated by market competition. However, allowing for the possibility of heterogeneous capabilities across firms and regions is a departure point from neoclassical economic theory where firms are assumed to operate in competitive markets governed by the Marshallian rules of 'single price' because they are assumed to have similar knowledge and capabilities.

Thus, neoclassical economic theory provides little theoretical basis for explaining how firms might survive with lower levels of productivity long enough to improve their productivity and become successful. The empirical evidence from industrial dynamics (Carlsson 1989) indicates that while some firms exit, others persist, even at low levels of profitability, and some of these eventually become more successful. Nor is there clear evidence that those still in the business are assured of economic sustainability as exits continue to occur (at a diminishing rate) as a specific entry cohort ages.

von Tunzelmann (2009a, pp 14-16) criticises the theory of economic growth of firms because it does not explain the origin of knowledge and technologies that firms obtain to produce their products (or services). Whereas some are produced 'in house' (e.g. R&D and production), others come from organisations called 'laboratories' (i.e.

[98] von Tunzelmann (2009a, p 12-13) explains that 'as Sen (1985) stresses, simply having a 'better' product says little or nothing about the individual consumer's capacity to benefit from those improved characteristics. First, consumers may find themselves in different *circumstances* that affect their extent of benefit (this includes, for instance, the impact of regulation, such as speed or pollution limits on cars). Second, individual consumers may have different *abilities* for reaping any such benefits (e.g. to drive a car safely). This combination of circumstances and abilities represents their *capabilities*. Some factors influencing capabilities may be (wholly or partly) under their own control as individuals, others may not be. We can think of different levels of *endowments* with regard to such capabilities, which include the individual's *competencies* (the level of relevant training, etc. attained) and their *capital* (accumulated wealth, tangible or intangible). We can also think of *enhancements* to their capabilities, most often from on-going learning and knowledge acquisition, especially through raising one's level of pertinent skills. Finally, we need to note that, as welfare economists emphasise, individuals may obtain different levels of *utility* (satisfaction) from the same level of capabilities'.

universities, suppliers of inputs, educational systems, etc.). [99] In firms, management aligns all these networks and the variety of capabilities of the individuals involved into a functioning productive processes. Explaining this alignment process as it occurs in specific locations can then be seen as the core of an RIS approach. However, there are important complications in doing this. First, the complex structure of interrelations provides no guarantee of complementarity. Producers may evolve their supply in an inappropriate way due to asymmetries of information, representing a waste of resources that may be costly to overcome. This might prevent them from tacitly agreeing to evolve in the same directions. Therefore, interactions involving information and knowledge exchange among actors may be necessary *ex ante* as well as market exchange *ex post.* Second, different actors may have different abilities for learning (absorptive capacity of the firms) knowledge that is generated elsewhere (e.g., other firms and organisations). Third, these interactions take place in an ever-changing environment. Therefore, decisions must be made in 'real time' (and almost never with a full appreciation of their full consequences). Then, in regional capabilities development, although the capabilities of each of the actors are important, the aggregation of their capabilities within the geographical space defined by their interactions is the way to address changes in a region (*ibid.*).

Additionally, von Tunzelmann (2009a) criticises existing RIS approaches because they do not explain how to start or regenerate a regional system. He proposes that this happens by replacing sets of traditional routines with new ones, through learning from

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[99] von Tunzelmann explains that 'laboratories' and the way they appropriate the benefits depends on their capabilities following an explanation of consumer capabilities (p 14-15). 'In laboratories, people with various scientific and technical competencies are employed to design and develop such 'technologies'. Again, their degree of success in doing so is conditioned by their 'capabilities'; in this case to produce not products but technologies. Profitability of a laboratory is given in part by the extent to which it can *appropriate* the benefits of the technologies it produces, e.g. through Intellectual Property Rights (IPRs). In practice, much of the twentieth century saw the movement of laboratories 'in house', i.e. within the firm, because of the need for close interactivity between the development of the technologies and the development of the products that used those technologies – and also to overcome IPR problems by internalizing them. This altered the organizational location of laboratories but not their function, and often not their geographical location.
Where do the scientists and technicians come from, with their competencies? They come from another institution, which we can label 'university', producing a certain type of 'human capital' with varying levels of capability. The procedure can be replicated successively – eventually we can build up not just a capability 'chain', but a whole capability 'network', drawing on the fact that producers (like firms) need a range of inputs, and not just technologies in a narrow sense. Apart from universities and educational systems (for human capital), they need supply chains (for materials and working capital), banks (for physical capital), governments (for public infrastructural capital), and so on.'

previous experience, using a strategy to create new strengths by blending the old with the new. However, it might be argued that there may be some cases in which this is true, but many others in which the new fundamentally displaces the old. The central discussion here is that actors need to find more effective means of cooperating in the interests of creating capabilities, for this intentionality is very important. This alignment involves coordinating heterogeneous capabilities of actors in a location to achieve mutually compatible outcomes that cannot be brought together by exercising power. They need public and private efforts, although network failure can also easily prevent this from happening. Thus, regional administrations have to promote policy capabilities to cope with complex contexts (von Tunzelmann 2009a, pp 17 and 27).

For the purpose of this thesis, one of the most important points in von Tunzelmann on the regional capabilities approach is the importance paid to learning mechanisms to explain the evolution of capabilities within a firm and/or a region. He argues that learning can be internal (e.g. R&D, production, design engineering, organisation, marketing, etc.) or external to firms, and may or may not involve industry-wide learning curves (i.e. experience) (Malerba 1992 cited by von Tunzelmann, 2009). He proposes a taxonomy of learning mechanisms, which is elaborated in Table 3.1.

Table 3.1 Taxonomy of learning mechanisms

External Source	Activity involved	Requires internal complementary learning
Spillovers from other producers	Production	Learning by doing
Suppliers of commodities	Consumption	Learning by using
Suppliers of capital good	Production	Learning by training
Knowledge suppliers	Research and technological upgrading	Learning by training/R&D

Source: Author's elaboration from von Tunzelmann 2009, p 442.

These learning mechanisms link specific sources of knowledge and activities. In each case, complementary internal learning (absorptive capacity) is necessary for external knowledge to be internalised, which depends on the position of the firm and the other actors. His argument for learning includes Zollo and Winter's (2002) [100] learning mechanisms in a time- and context-dependent environment. Since time is taken up by changing routines and practices, a successful competitive firm has to anticipate changes

[100] Zollo and Winter (2002) suggest that dynamic capabilities are shaped by internal coevolution of the learning mechanism developed from internal operating routines, which comprise i) relatively passive experience accumulation, ii) explicit knowledge accumulation, and iii) knowledge codification processes.

of markets and technologies and direct its capabilities to the present and future capabilities of consumers and suppliers (von Tunzelmann 2009, p 444).

It could be argued that this *ex ante process* would be useful when regions are able to anticipate future changes in the economic environment (e.g. GATT and NAFTA) or go for regeneration, as von Tunzelmann (2009a) explains. However, the rather passive experience accumulation and appropriability of knowledge would influence the speed of regional change. This might be more visible in mature industries and/or developing countries/regions. However, it might be an optimal path for development in the traditional sectors of developing countries or in regions seeking regeneration (von Tunzelmann and Acha 2005; von Tunzelmann 2009a). Thus, learning can be undertaken in a pro-active way or can be seen as a natural by product of experience and efforts to achieve better performances. However, it is not obvious whether a pro-active approach or one aimed at exploiting experience is best.[101] Another of the limitations of the von Tunzelmann (2009a) approach is that it does not suggest a specific way of testing it.

Summarising von Tunzelmann's regional capabilities proposal, regions have actors, each of them with unique capabilities. For regions to advance their capabilities, regional actors need to change their routines in a coordinated way and then, regional capabilities would be interactive[102] and dynamic. That is to say, regional capabilities change in a context where firms' suppliers and consumers' needs and abilities coevolve. However, these changes in capabilities require alignment of actors' aims and coordination of activities and processes as well as allocation of specific resources. In this context, timing is important because the learning curves are time- and context-dependent (e.g. absorptive capacities of firms and other regional actors). These are the basic requirements for regional capabilities change, and the emphasis is shifted from co-location of actors to coevolution of their capabilities (von Tunzelmann 2009a, p 16).

[101] A pro-active approach assumes that doing something is better than doing nothing. However, since it has costs (including the costs of diverting attention to more explicit efforts at learning rather than just getting on with it), it is not clear that benefits will exceed costs. Alternatively, it may be better to devote effort to identifying and resolving problems, bottlenecks and barriers rather than attempting to improve mechanisms by whatever type of learning (the accumulation of knowledge) occurs.
[102] Interactive refers to well known forms of quality control, zero defects and just-in-time – in other words, flexibility of mass production to achieve not just greater throughput but less downtime and more systemic operation of equipment, plan and productive systems (von Tunzelmann 2009a, p 19).

Whereas von Tunzelmann focuses on an inward analysis of regional actors and their interactions, Cooke (2005) emphasises that this ‘internal’ development process is also an outgrowth of and, to some extent, a more externally-driven process of development. That is to say, Cook and von Tunzelmann can be seen as complementary approaches.

For the renewal of a region in a high tech sector, Cooke (2005) argues that RIS research creates a revised theory of economic geography based on ‘regional knowledge capabilities’ or a ‘ground-up’ knowledge-driven process (Globalisation 2), which is overtaking the earlier ‘top–down’ multilateral trade institutions, i.e. corporately driven approach (Globalisation 1) (p 1128 and 1130). He further argues that ‘regional knowledge capabilities’ are based on the transmission of ‘localised knowledge spillovers’ among firms and other organisations, which may not be local and when knowledge spillovers are present, they stimulate knowledge transfer rapidly and continuously for upgrading of the regions’ actors and institutions. Thus, spillovers explain firms ‘dynamic capabilities’ improvement in a way that is compatible with a resource-based view (2005, p 1147).

Cooke (2005) tested his proposal in pharmaceutical and agro-food biotechnology sectors in the canton of Basel in Switzerland. He found that although the region had a research structure (i.e. public research organisations with ‘bio scientific capabilities’) to serve local large bio pharmaceutical firms (i.e. Novartis, Roche, Syngenta and Lonza); these firms also created regional-global interactions (mainly with research organisations in the US) or open innovation to overcome, complement and progress the region’s capabilities. Furthermore, these interactions became a systemic institutional networking (Cook 2005, p 1131). He concludes that a successful economic region is one that has all or most of the key value-adding functions of a specific sector as well as a reasonable diversification of the economic base or connected sectors, thus combining depth and breadth in its industrial capabilities (Cooke 2005, p 1137).

It can be argued that this is to be expected because complementarities of capabilities between large biotech firms and other research organisations are less costly than creating them in-house and/or might take longer to develop. While these complementarities may also occur in other sectors and regions, they will often be smaller in scale or involve different types of partnerships because the knowledge and capabilities that are sought may be less specialised than those of the biotech industry.[103]

To provide an example of the regeneration of two regions in line with von Tunzelmann (2009a), Heidenreich (2005) illustrates how two German industrial cities renewed their regional capabilities facing economic and technological uncertainties. Heidenreich argues that the 'creation and evolution of these regional capabilities are the result of strategic interaction, regional governance structures and regionally available possibilities for the integration of heterogeneous, explicit and implicit knowledge. An essential dimension of the regional capabilities is also that the ways in which regions facilitate interorganisational learning processes cannot be taken for granted, but have to be carefully monitored'. Thus, '*regional capabilities* can be defined as the capacity to create and provide collective competition goods and to stimulate and stabilise communication and cooperation between regional companies, schools, universities, technology transfer, research and development facilities and political and administrative actors. These goods and networks support the innovative capability of regional firms, this is "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece, Pisano et al., 1997, p 516)' (Heidenreich 2005, p 742). The author provides an explicit formulation on how (i.e. processes) those regional capabilities evolved in regions. These processes are the strategic interactions, regional governance structuring, and inter organisational learning among actors with heterogeneous knowledge.

Heidenreich (2005) also stresses that the innovativeness of a region depends on its ability to recombine technological, organisational and scientific capabilities and that regional policies facilitate this recombination (p 739). He argues that in an economic environment with open competition and greater uncertainty, regions respond using different strategies based on a decentralised coordination between organisations and institutions. The decentralised coordination has to be capable of re-evaluating and revising goals that enable the recursive and mutually adjusting development of strategies addressing specific capabilities and avoiding the fashionable high tech list. This case clearly identifies the importance of the changes of industries, in which many

[103] This is a science-based industry based on analytical knowledge as proposed by Asheim and Coenen (2006).

firms were integrated and others disappeared and there were changes in the institutional learning processes, which coevolved in a open and competitive world (i.e. ‘experimental regionalism’) [104] (Heidenreich 2005).

In a developing context, and in an attempt to integrate the micro and meso levels as suggested by von Tunzelmann (2009a), and to understand the impact of an external source of knowledge for the development of regional capabilities as recognised by Cooke (2005), Padilla Pérez (2006) provides an example on how technological capabilities at firm level (technological capabilities in the tradition of Bell and Pavitt 1993; Lall 1993) changed by the FDI impact on the technological building capability in the host country. He compared two regions in the manufacturing of electronics, where firms mainly serve the international market. He defines regional technological capabilities as ‘knowledge and skills embedded in individuals, organisations and institutions located in a geographically-bounded area and conducive to innovative activity’ (Padilla Pérez 2006, p 69). He found that technological learning that builds up those capabilities is a result of complex interactions among individuals and organisations. He highlights that regional factors, knowledge and skills need to be present in firms and other organisations, as conditions for regional innovative activities. This approach is unique because it combines quantitative and qualitative methods to integrate the micro and meso levels, and possible to carry out because of the features of the industry, i.e. a small number of firms using similar technologies (unlike the case of agribusiness as explained in section 3.1). Whereas knowledge and skills are two of the factors that describe ‘capabilities’, this research in agribusiness pursues a learning system approach based on understanding the changes in the micro processes that changed the knowledge and skills of the actors in the regions to improve their capabilities.

In brief, RIS theoretical foundations are focused on the importance of the regional location of firms and other organisations, and their interactions which are important for explaining the creation and exchange of tacit and codified knowledge (Maskell and Malmberg 1999; Gertler 2001; Gertler 2003; Asheim and Gertler 2005). Regional

[104] ‘experimental regionalisms’ aim at creating an organisation capable of revaluating and revising its substantive purposes. Thus, experimental institutions will find out and adjust means and ends accordingly (Sabel 1996, quoted by Heindenreich, 2005, p 743).

capabilities, on the other hand, elaborate a larger strand of RIS theory, specifically, one that problematises the significance of alignment of actors' aims and the coordination of collective activities (von Tunzelmann 2009a), which also includes the external influence (MNCs and FDI) as discussed by Cooke (2005) towards region-specific or local capabilities development. The regional capabilities approach, as suggested by von Tunzelmann (2009a) goes further, proposing theoretical foundations for regional capabilities building, which attempt the integration of the micro-meso level explained by coevolution of supplier-producer capabilities focusing on changes in routines. These changes, eventually explain the dynamics and growth of regions.

From our perspective, the regional capabilities approach could attempt an even higher level of aggregation – the country – as addressed by von Tunzelman (2009a), if more attention is paid to the role of institutions in the alignment and coordination of actors' interactions at regional and national levels, as proposed by Howell (1999), Cantwell and Iammarino (2003) and Iammarino (2005). Thus, in the coevolution of actors' capabilities in the regions, the processes of alignment and coordination of actors' interactions are fundamental for the creation and exchange of tacit and codified knowledge, i.e. learning processes, for regional capabilities building. However, neither RIS nor regional capabilities proponents explain how knowledge is created and exchanged when there is low mobility of resources, which seems likely to be important in explaining how traditional routines are improved and/or replaced by new ones in traditional sectors. As noted in this section, this replacement or renewal process is not a linear one of knowledge diffusion as explained by Cooke (2005). It requires the coevolution of intra and inter organisational knowledge and skills, which are internal to firms and other regional actors and/or include the supply from FDI (e.g. Padilla Pérez, 2006) and from external laboratories as identified by Cooke (2005) in the case of biotechnology to improve the capabilities of local firms and regions.

The main shortcomings of von Tunzelmann's proposal are a) it does not approach empirical application sufficiently to provide a reliable guide to identify what capabilities of numerous small firms (i.e. in our case, the farmers and dairy processors) should be examined for changes due to actor interactions in the regions; and b) it does not set a systemic framework for examining how these changes occur, i.e. how they are supported by other organisations seeking to support economic growth. An approach that addressed these issues might provide insights for policy making aiming to support capabilities development of regions that are already advanced and/or to improve the capabilities of regions that are lagging behind.

Additional theoretical issues will be explored further in the following sections: a) the importance of the specificities of the knowledge and technologies in a sector (section 3.3) which helps address the problem of identifying which capabilities might be important; b) collective interactions by which tacit knowledge is produced and exchanged within and between firms, including other organisations (i.e. intra and inter relationships of actors) in a local space; in other words, to identify and analyse the activities, processes and mechanisms by which capabilities change within firms, organisations and regions (section 3.4). The final issue is to examine how these understandings about specific capabilities and their systemic construction might be related to policies aimed at improving economic performance in regions (which is examined in section 3.5).

3.3 Sectoral innovation systems (SIS) approach

Although regional innovation studies often consider specific industries by way of illustrating the abstract arguments concerning learning and actors' interactions, they provide relatively little basis for concluding that the factors they identify as central are equally applicable to all industries and it is noteworthy that they often employ examples drawn from high technology industries. Using specific industries as examples does have the merit that the abstract analysis is considered in the light of experience, but the specificities of high technology industries direct more attention to knowledge generation (mainly in R&D labs and research organisations as in the case explained by Cooke, 2005) than to knowledge exploitation, exchange and diffusion. Even more significantly, this attention to rapid technological change regimes reduces attention to the persistence and inertia of existing practices and routines in traditional sectors. One of the main reasons is that high technology industries might be engaged in a process of fast renewal, the technologies of yesterday are not adequate for the challenges of tomorrow, and they must be altered substantially today.

In the systems of innovation family, the SIS approach claims to provide understanding of sources of the knowledge environment (e.g. learning, skills, artefacts) and the technological regimes (Malerba 2005, p 382 citing Nelson and Winter, 1982) influencing specific sectors or industries. In constructing an understanding of environment and regime, SIS studies often define the specific problems that firms have to solve in their innovation processes, which affect their technological learning and the dynamics of the evolution of their sector. Even if some studies do not consider the detail of specific problems, almost all provide insight into characteristics of the knowledge base, its appropriability and degree of cumulativeness. These aspects complement and integrate the micro-meso (and perhaps macro) dynamics of an industry in a specific region and possibly in a country. Furthermore, it helps to analyse consistently the commonalities and differences in sectoral growth (Malerba 2005) among regions and countries.

Malerba (2005, p 385) states that ‘a sector is a set of activities that are unified by some linked product groups for a given or emerging demand and which share some common knowledge’. From this definition, it is possible to identify the sets of activities, procedures and routines that constitute the main technological components embedded in an agribusiness. This is the primary reason for including the SIS approach in this thesis because we consider in some detail the specificities of a particular technological model (i.e. the Holstein model) for milk production, the implementation of which differs among the regions. Viewing the MDS as a SIS provides some specific methods for identifying and analysing the parts of the sector that extend outside the region but that are, nonetheless, part of the innovation system influencing regional opportunities and performance. For instance, the processes of knowledge creation and evolution via training programmes are outside the sector. By examining these factors, it is possible to understand better the heterogeneity at the level of firms and regions.

In the SIS approach, the processes for transformation of the industries do not consider sectoral boundaries as given and static (Malerba 2004; Malerba 2005). Therefore, sources of innovation can come from everywhere (local or global) (Cooke 2005). Actors in a region are the ones that create the patterns of innovation change because over time, a SIS undergoes processes of incremental change in its components (Malerba 2002, pp

247-248).[105] Thus, analysing the knowledge and technologies of the production systems, it is possible to understand the appropriability and cumulativeness of the knowledge base in capabilities development; that means, to understand the mechanisms by which individuals in firms and organisations in systems articulate the knowledge to change routines and improve and evolve capabilities. Because appropriability and cumulativeness of knowledge may not be similar throughout the regions, the ability to generate and exploit opportunities relies on actors' capabilities within regions. Moreover, assessing the prospects for sectoral advance may also require the demand of knowledge in the sector to be considered, the need for complementary organisations (as von Tunzelmann, 2009a, has already noted), e.g. the availability of research organisations and universities, the structure of the industry, vertical and horizontal integration among local firms, and user and producer interactions (Nelson 1993 cited in Malerba 2002).

In seeking a better understanding of the nature and complementarity of technologies involved in agribusiness, it is essential to trace the interdependencies between technical and organisational changes and the sources for innovation (Freeman 1995). Understanding the interdependence is necessary for effective regional policies, which nevertheless have implications for a national policy, the latter because sources of knowledge and technologies are not only within regions (Metcalfe 1995). Furthermore, national differences in innovative capabilities strongly influence national performance, which, in turn is affected by globalisation processes. However, regionalisation and localised knowledge are important because they provide a source of diversity, which may be more effective in producing economically sustainable paths than pursuing standardisation and convergence.[106] Preserving and even encouraging diversity may outweigh the short-term advantages of the scale economies derived from standardisation, and their propagation through MNCs, free trade and FDI. Therefore, both processes, i.e. global standardisation in some areas, but increasing diversity in others, co-exist (Freeman 1995).

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[105] See the basic elements of the MDS using the proposal of Malerba (2002) in section 2.2.

[106] This argument about the role of MNCs in globalisation is taken up by Freeman (1995, p 16), who states that even in the case of consumer goods MNCs take advantage of the surviving differences between nations in terms of capital, labour, energy and other input costs.

The integrated views of RIS and SIS approaches bring us back to the empirical issues (i.e. technological and organisational processes for the progress of the regions, differences in the systems of milk and dairy production, the localised character of knowledge production and learning and the sources of knowledge) explained in section 3.1 for selection of the literature. RIS approaches provide the analytical elements for understanding the learning processes that support the regional progress based on the creation and exchange of tacit and codified knowledge in specific spaces under different institutional set-ups. The regional capabilities approach advances our understanding in looking at the coevolution of supplier-producer capabilities as interconnected processes to explain regional capabilities rooted in the processes of changing routines. They involve processes where the alignment of aims of actors and coordination of activities are fundamental for the coevolution of capabilities to occur. SIS approach, on the other hand, explains the analytical features (i.e. nature of sector knowledge base, its appropriability and degree of cumulativeness), which define the processes of capabilities development in a sector within a region and possibly a country.

If one assumes that industrial specificities matter, it is necessary to pursue deeply the study of industry-specific capabilities. In addition, much of the literature on RIS has employed high technology industries which obscure the important role of persistence or inertia in the routines of firms/organisations that must be overcome in order to renew or ‘upgrade’ the sector to higher levels of performance. Hence, a closer theoretical examination of the micro processes for capabilities evolution, i.e. routines or organisational routines in firms, is needed. Thus, the literature of dynamic capabilities provides further understanding for the missed link, micro-meso level integrations, inter organisational capabilities.

3.4 Identifying relevant capabilities in firms and the processes of change

As already explained, in agribusiness factors of production are less mobile, local knowledge may play a more central role, routines are persistent and subject to inertia and new knowledge about production must, for the most part, be absorbed by individuals who are likely to be sceptical of ‘outsider’ knowledge. Therefore, in this section we take a critical position regarding the parts of the literature which focus on capabilities development in firms in mass production and high technology sectors, i.e.

dynamic capabilities approach, which has received most of the attention. This critical review of the literature will help the current research in three ways: a) to consider how the micro processes are identified, i.e. routines which lead to changes of capabilities in firms and organisations; b) to understand how firms bring together the sources of knowledge that help them to renew their capabilities and eventually the capabilities of the regions in which they are located; and c) to build a concept of sector-specific regional capabilities, which need to be identified and analysed for policy recommendations. These aspects have been acknowledged by von Tunzelmann (2009a) who also claims that within a region, actors perform their roles in a persistent way over time based on past experience, with some gradual evolution in this performance. This implies that it is important to observe the processes that lead to regeneration of regional agribusinesses, which are experiencing incremental innovation, as evidenced by this thesis.

A specific feature of the MDS is the persistence of the technological and organisational processes that need to be changed to allow progress in firms and regions. The analysis of these processes in firms using a dynamic capabilities approach constitutes the bases for understanding the integration of the micro-meso level of capabilities for purposes of development and evolution.

To proceed to a deeper understanding of capabilities from a firm perspective in a developing context, we propose a specific definition of capabilities for this research. A capability is the capacity[107] to act, perform or do something successfully.[108] A capability, ‘whether operational or dynamic, is the ability to perform a particular task’ (Helfat, Finkelstein et al. 2007, p 1). So, ‘To be capable of something means to have a generally reliable capacity to bring that thing about as a result of an intended action. Capabilities fill the gap between intention and outcome...’ so that ‘outcome bears a definite resemblance to what was intended’ (Dosi, Nelson et al. 2000, p 2).

Capabilities intrinsically involve capacities to adapt, adjust, re-orient or re-calibrate activities, procedures, patterns of behaviour and routines to reproduce successful performances under changing conditions. Hence, capabilities necessarily also involve

[107]To avoid using the word ‘ability’. Here, it also stands for ‘experience’, ‘quality’ and/or ‘attribute’.
[108] Having achieved a desired aim. It does not imply outstanding performance.

the capacity to alter routines. For routines, we emphasise the rigidity of their formulae, recipes or procedures, and the necessity for their re-enactment over time in order to maintain reliability and predictability. These features of routines provide ways of suppressing harmful variety (deviance) as described by many authors (e.g. routines as structures to accomplish organisational work, Feldman, 2000, p 1). However, definitions in the literature often fail to be specific about issues of rigidity and persistence. For instance, a routine has been described 'as [a] synonym for "pattern of recurring routinized behaviour"' (Cohen, Burkhart et al. 1996, p 695). This raises questions about how often 'recurrence' needs to occur before routinised behaviour becomes a 'routine'. The same authors take routine 'to be a synonymous with procedure, i.e. a set of rules that generates repetitive behaviours' (Cohen, Burkhart et al. 1996, p 695).[109] In addition to questions about duration of 'repetitive behaviours', this definition further confuses the specificity of routines by introducing the idea that rules may *generate* such behaviours. The fuzziness of when, how, and to what extent this 'generation' activity might occur is not very helpful. By contrast, Nelson and Winter (1982) are more helpful regarding the issues of persistence in their definition of routines as 'organisational truce' which reminds us of the reasons why rigidities are introduced. However, Nelson and Winter (1982, p 14 and 18) also define a routine as 'all regular and predictable behavioural patterns of firms'. Again, this creates confusion about the issues of rigidity as well as further complications for assessing the boundaries of behavioural patterns that might be considered as routines. However, Nelson and Winter do usefully identify the issue of change in routines, which they call a mutation. By taking a more specific definition of routines as involving rigidity, persistence and specificity, this thesis is better prepared to consider what a 'mutation' or change in routine might involve. In subsection 3.4.2, we will explain how these more tightly defined routines and the possibility of their change provide some of the building blocks of capabilities in firms and eventually in regions, and then in subsections 3.4.4 and 3.4.5, how firms alter routines as sources of change of regional capabilities.

In understanding the persistence or inertia and the processes of change of routines, the literature of dynamic capabilities helps us to explain changes in routines (i.e. intra organisational routines) as involving individuals' interactions *within* firms, and

[109] For an extensive discussion about routines and patterns of behaviour, see Cohen, Burkhart et al. (1996).

individuals of one organisation interacting with individuals from other organisations (e.g. suppliers, research organisations, universities, etc.). These individuals from other organisations may also change their intra organisational routines and create processes that support inter organisational capabilities changes in a local space. These understandings are helpful to explain the coevolution of intra and inter organisational capabilities, which this thesis argues make up the capabilities of larger systems/regions/industries and possibly countries, as von Tunzelmann (2009a) proposed. Furthermore, these interactions explain further the specificities of the knowledge and technologies of the suppliers and help us to understand the distinction between technological and organisational capabilities and the processes associated with their changes (see subsection 3.4.3).

Changes in micro processes, i.e. routines, seem likely to involve learning processes (organisational and institutional), which help explain the integration of micro-meso levels for regional capabilities building. The existence of these underlying learning processes is inferred by changes at a meso level and validated by evidence concerning the collective activities; processes and mechanisms of various actors that are consistent with these changes or instances of the existence of changes in the routines and then capabilities of firms and organisations (see subsection 3.4.5). This approach is more useful for observing broader patterns of change than for assigning responsibility for specific turning points in innovation. In other words, it may be more useful to examine systemic changes than to identify specific innovations or innovators within a system/region. By identifying systemic change it becomes possible to arrange or position individual innovations within a context and examine how relationships between these innovations contribute to or impede sectoral progress.

In particular, this approach is relevant in a catching up process where many actors may contribute to the adaptation of knowledge and technologies or the localisation of an innovation already in use in other parts of the world. It is also useful in cases made up of many interdependent and complementary technological components (e.g. agribusiness) that greatly reduce the significance of the specific novelty often associated with innovation.

In the following discussion of firm capabilities, we need to focus on the stylised features of agribusiness already addressed by the SIS approach (i.e. characteristics of the sector knowledge base, its appropriability and degree of cumulativeness) for which the meso level features can be explored using the RIS (i.e. technological and organisational processes for the progress of regions, differences in the systems of milk and dairy production, the localised character of knowledge production and learning and the sources of knowledge).

Subsection 3.4.1 discusses the concept of dynamic capabilities to explain how dynamic capabilities evolve based on changes in organisational routines. Subsection 3.4.2 looks at organisational routines as some of the building blocks of capabilities. Subsection 3.4.3 differentiates between technological and organisational to better understand the coevolution of regional capabilities between the suppliers and users of knowledge and technologies, and as a means of structuring specific interventions, relevant to policy analysis. Subsection 3.4.4 discusses the learning processes based on the interactions of actors for capabilities building. Subsection 3.4.5 discusses how capabilities evolve in systems and regions based on the interactions of actors in a region.

3.4.1 Dynamic capabilities in firms and organisations

The aim of this section is to critically analyse the literature of dynamic capabilities in order to identify relevant capabilities for agribusinesses that are subject to systemic change to improve the economic sustainability of the regions.

As we defined before in section 3.4, capability is the capacity to act, perform or do something successfully. For this research, capabilities intrinsically involve capacities to adapt, adjust, re-orient or re-calibrate activities, procedures, patterns of behaviour and routines to reproduce successful performance under changing conditions. Thus, proponents of dynamic capabilities propose to explain how these firm capabilities change and suggest that these changes are the results of individuals interacting internally with other individuals and also interacting with individuals from other organisations. However, the present literature of dynamic capabilities focuses more on the internal interactions between individuals.

The dynamic capabilities framework is widely used to explain how firms create and sustain competitive advantage over time (Leonard Barton 1995). Dynamic capabilities concern change (Helfat, Finkelstein et al. 2007, p 1). The framework explains in many different ways that a ‘dynamic capability is the capacity of an organization to consistently nurture, adapt, and regenerate its knowledge base, and to develop and retain the organizational capabilities that translate that knowledge base into useful actions’ (Iansiti and Clark 1994, p 563), or a ‘dynamic capability is the capacity of an organisation to purposefully create, extend, or modify its resource base’ (Helfat, Finkelstein et al. 2007, 4).

This literature of dynamic capabilities has directed particular attention to changes in firms because of 1) changes in the economic environment which occur over time and require adaptation by the firm (Iansiti and Clark 1994; Teece and Pisano 1994; Teece, Pisano et al. 1997; Dosi, Nelson et al. 2000; Eisenhardt and Martin 2000); 2) changes in the business environment (Leoncini, Montresor et al. 2003); 3) changes in the rapid technological environment for the catching up of countries (Bell and Pavitt 1993; Dosi, Nelson et al. 2000); and 4) changes in the markets (Eisenhardt and Martin 2000; Griffith and Harvey 2001).

Whereas most of these literature proponents focus on particular firms in developed contexts where rapid change and/or fundamental transformation of firms and sectors are very important for creating competitive advantages to succeed, none of them address the more incremental innovations for changes in capabilities that happen in traditional sectors, e.g. agribusiness; which have a more continuous and evolutionary character.

For instance, Teece, Pisano et al. (1997, p 517) propose that a dynamic capability is a ‘firm’s ability to integrate, build and reconfigure internal and external knowledge to address rapidly changing environments’. Whereas Teece, Pisano et al. are interested in the fundamental transformation from a more passive form of organisation to one which is characterised by continuous innovation to face rapid changes in the business environment, Leonard Barton (1995) attempts to distinguish static (basic, elementary, stable, recurring, foundational, etc.) from dynamic (co-evolving, changing as the result of experience, and adapting to environment). The latter seems to be closer to the case of agribusiness.

Zollo and Winter (2002) stress that in the definition of dynamic capabilities of Teece, Pisano et al. (1997), the authors do not state from where they come. Zollo and Winter (2000) propose that 'a dynamic capability is a learned and stable pattern of collective activities through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness' (p 340). They argue that 'learned and stable pattern' and 'systematically' highlight the structure and persistence of a dynamic capability. They illustrate a dynamic capability[110] in several ways: a) organisations adapting operating processes through a relatively stable activity dedicated to process improvements; b) organisations developing projects in a systematic and relatively predictable fashion (e.g. acquisitions or joint ventures); and c) organisations executing effectively post-acquisition integration processes, which involve the modification of operating routines in both the acquired and the acquiring unit (Zollo and Winter 2002, p 340).

One might conclude that dynamic capabilities change because firms change their operational routines in conjunction with making organisational changes (Zollo and Winter 1999; Zollo, Reuer et al. 2002; Zollo and Winter 2002; Winter 2003) and suggest that routines or organisational routines or operational routines are some of the building blocks of capabilities more generally (Dosi, Nelson et al. 2000; Zollo, Reuer et al. 2002; Zollo and Winter 2002; Winter 2003; Winter 2003a). Thus, the process of capabilities building means that capabilities evolve and accumulate over time and that this requires the reconfiguration of their resources (Penrose 1995).

Dynamic capabilities evolution is the antecedent to organisational and strategic decisions that allow managers, regardless of the type of organisation (i.e. both profit and non-profit organisations), to alter their resource base to generate new value-creating plans for their organisations (Eisenhardt and Martin 2000) and which, when successful,

[110] This is in line with Dougherty, Barnard et al. (2004, p 1) who argue that: Capability is the potential or propensity to do things not the things that have been done. Therefore, this structuring of everyday work is the capability; and it becomes *dynamic* because three sets of rules and resources animate it: 1) taking responsibility for the entire process, which provides people with the resource of time; 2) valuing knowledge and expertise, which provides the authority to act; and 3) searching for opportunities, which provides options to address the inevitable surprises in innovation activities. These rules and resources invoke routines that enable people to map innovation work in time, generalise specialised knowledge to make it accessible to others, and keep open a variety of options to solve problems.

influence the entire industry/system. From here, it could be said that other actors or organisations in an innovation system (e.g. government organisations, universities, financial organisations, etc.) also develop dynamic capabilities and deploy them in their interactions with firms (Meeus, Oeerlemans et al. 1999; Coriat and Weinstein 2002).[111] Following this argument, innovation systems develop capabilities when firms have the propensity to integrate, to build upon and recombine knowledge and resources (Dougherty, Barnard et al. 2004) from other organisations (i.e. competitors, suppliers and related government organisations) and effectively to deploy their inter organisational routines and capabilities (Fujimoto 2001; Macpherson, Jones et al. 2004; Zollo and Singh 2004).

3.4.2 Organisational routines as the building blocks of capabilities

This thesis argues that organisational routines (not the routines of an individual[112]), 'have the major function of coordinating the skills of the organization, i.e. turning that collectivity of skills to useful effect' (Dosi, Nelson et al. 2000, p 5). Organisational routines which have been referred to as 'repeated patterns of behaviour that are bounded by rules and customs and that do not change very much from one iteration to another' (Feldman 2000, p 611), are some of the micro foundation processes of capabilities evolution within firms and organisations. In this way, it is possible to differentiate organisational routines from capabilities, following Dosi, Nelson et al. (2000, p 4), who argue that routines are some of the building blocks[113] of a capability and 'capability is a fairly large-scale unit of analysis, one that has a recognizable purpose expressed in terms of the significant outcome it is supposed to enable, and it is significantly shaped by conscious decision both in the development and the deployment'.[114] Thus, it could

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[111] Coriat and Weinstein (2002) assert that innovation is the result of the interaction between different types of organisations and not just the product of the activity of firms only. This is a systemic process in which the variety of the agents involved in the process of innovation and their modes of interaction among them, i.e. between firms themselves and between firms and other types of organization, define the development of dynamic capabilities.

[112] Routines of individuals are their skills (Nelson and Winter 1982, p 73).

[113] Other building blocks are individual skills and artefacts (Dosi, Nelson et al. 2000, p 4).

[114] Dosi, Nelson et al. (2000, 4) proceed to argue that 'These features distinguish "capability" from "organizational routines" as that term is used in organization theory and evolutionary economics—subject to the qualification that *some* organizational routines might equally well be called capabilities. In general, however, the notion of a routine involves no commitment regarding size—large routines are typically structured sets of medium-sized routines, and so on. It involves no presumption regarding evident purpose; one of the interesting things about routines is that they are often found in contexts where nobody can explain what they are for except in the vague terms of "the way things are done around here". And

also be said that organisational routines are 'critical building blocks for broader assemblages of capabilities. In some cases, these broader assemblages of capabilities become a sufficiently distinct and coherent set of practices that they are given a label, such as the Fordist or Toyota production system' (Levinthal 2000, p 366); which might include R&D capabilities, engineering capabilities, operations and production capabilities.

In seeking to identify specific capabilities and achieve a better understanding of the processes that build regional capabilities, it is important to decompose them into blocks of routines, which are related to specific technological components and organisational processes (see the following section 3.4.3). In so doing, it is possible to get greater insight into the sources of knowledge and the learning processes and the specific routines that lead to major changes. This decomposition is of particular interest in this research, e.g. we are interested in routines underlying capabilities improvement and development of current processes of production and/or the development of new products. Empirically, this is an important issue in identifying and analysing changes in capabilities of small firms because when researchers have attempted to apply a resource-based view in a developing economy context, they face greater disparities in the competitiveness of firms (e.g., Cervantes Escoto, Santoyo Cortés et al. 2001; Salas Quintanal 2002; Muñoz Rodríguez, García Muñiz et al. 2003). Some of the reasons for these disparities may be the result of access of these firms to knowledge and technologies and other complementary resources that are inputs for building capabilities, which might or might not be available in a region or a system. Or even if they are available in the systems, they might need specific channels for users to access them. In this sense, the question is whether regional and systemic resources are available to firms as a substitute for the possession or development of these resources by the firms.

Understanding organisational routines is therefore a major step in understanding capabilities building, which are described in different ways in the literature – for instance, replacing more or less traditional routines in the words of von Tunzelmann

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there is no presumption of deliberation or conscious choice; a flight crew probably does not choose its response to unexpected turbulence any more than a batter chooses to hit the dirt when the pitch appears to be coming toward his head. On the other hand, the notion of a routine certainly does not *exclude* the possibility of conscious decisions about exercise. Hence, some routines may appropriately be called capabilities, if they satisfy the other criteria'.

(2009a, p 17), or changing low levels of capabilities into higher levels of capabilities in the words of Winter (2003) and Zollo and Winter (2002). That means that an alternative set of routines would be better, with the knowledge and learning of how to implement or at least begin to implement the alternative. However, these explanations do not further explain how these processes happen.

This thesis proposes that individuals in firms/organisations, who have knowledge and skills, combined with artefacts (and possibly other complementary inputs), are able to carry out individual routines. But individual routines do not stand alone, they are usually linked to other routines within a firm (Levinthal 2000; Narduzzo, Rocco et al. 2002). The family of related routines will be referred to as 'organisational routines' in this research. When these organisational routines are changed by individuals and coordinated and organised in different ways by those individuals and managers, the output may be improved and/or new intra organisational capabilities created. In other words, an organisational capability is then 'a high-level routine (or collection of routines) that, together with its implementing input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type' Winter (2003, p 991).

Considering organisational routines in a specific way helps to explain the resistance to change, but it also provides a stronger and richer basis for grounding improved and new capabilities with specific content of knowledge. Organisational routines involve patterns of behaviour founded in part on tacit knowledge which are performed repeatedly, but which might change if environmental conditions change (Winter 2003; Becker 2004). In effect, these routines are the repositories of knowledge in the firms (Nelson and Winter 1982) and store particular types of tacit knowledge (e.g. ISO 9000) (Lazaric and Denis 2001; Lazaric and Denis 2005) because they represent successful solutions to particular problems (Teece and Pisano 1994; Teece, Pisano et al. 1997; Dosi, Nelson et al. 2000; Zollo and Winter 2002). They are highly situated and have a cognitive dimension that is scripted in individuals' mental models (Nonaka 1991; Ambrosini and Bowman 2001). However, they are often idiosyncratic in their detail (Eisenhardt and Martin 2000). When one organisation tries to imitate another, the set of organisational routines can only be replicated to a certain extent because of the differences of the knowledge and skills of individuals, organisational history, culture and external environments, which will interfere with the replication process (Zollo, Reuer et al. 2002; Becker and Lazaric 2003).

Organisational routines (or search routines in the language of Nelson and Winter, 1982) increase the potential to focus on non-routine events, e.g. innovation, by economising on cognition and negotiation when individuals set out new ways of doing things (Becker 2004; Becker, Knudsen et al. 2006). The processes of change in organisational routines occur because of a participant's reflection on and reactions to various outcomes of previous iterations of routine. The agent therefore is important for understanding the role of organisational routines in learning and in processes of institutionalisation (Feldman 2000) in firms and systems. Therefore, acknowledging the agent in organisational routines provides a different and complementary way of viewing routines as rigid procedures and/or patterns of recurring routinised behaviour (Cohen, Burkhart et al. 1996) and as sources of change in capabilities (Feldman 2000).

3.4.3 Technological and organisational capabilities

In this section, we discuss some issues regarding the distinction of technological and organisational capabilities in the literature, because it has been argued that 'organisational transformations are linked to technological change' (Coriat and Weinstein 2002, p 277). This constitutes one of the bases of innovation system literature. For this research, an effort to make this distinction is useful for three reasons: 1) to identify and explain the differences in the use of a specific technological model (i.e. the Holstein model) and ways of organising the production and distribution of knowledge in local settings; 2) to construct the concept of sector-specific regional capabilities and a way of integrating the micro and meso levels of analysis; and 3) to improve policy making.

Making a distinction between organisational and technological routines is a challenge. It is difficult to establish a clear-cut difference between them within a firm because of the infeasibility of gathering extensive evidence at a micro level (i.e. the state of advance of each of the actors over time). However, meso level evidence of the changes of capabilities of firms in specific regions allows an inferred coevolution of the technological and organisational capabilities and their sources in routines embedding specific knowledge and technologies. Addressing the question of how regional capabilities are developed to pursue the sustainability of an activity such as dairy production in a region requires, on the one hand, examination of changes in firms' capabilities, their knowledge and the technologies in use. On the other hand, it is also necessary to examine changes in the organisation of the work, in the interactions of the firms (e.g. the arrangements for integrating the value chain and the delivery of the training programmes) and in institutions of the systems/regions. By distinguishing these categories and achieving a better understanding of the sources of the knowledge and technologies, it is possible to have a clearer view about the coevolution of regional capabilities. This effort at classification is consistent with Levinthal (2000, p 366) who argues that broader assemblages of capabilities become sufficiently distinct and are given a label.

In the search for a regional capabilities concept, this thesis proposes that it is possible to distinguish two different groups of capabilities related to their knowledge content, i.e. technological and organisational capabilities. This is consistent with Malerba (2005) for understanding the nature of knowledge of the sector and its appropriability and cumulativeness, which are central features of capabilities building. However, these two categories of capabilities are intertwined and they progress as they coevolve.

The literature of capabilities distinguishes either organisational or technological capabilities, but very few deal with both[115] (von Tunzelmann 2009). Whereas most of the literature on dynamic capabilities subsumes and/or intertwines the technological aspects (i.e. specific knowledge and artefacts) of capabilities when they discuss other building blocks of capabilities (e.g. see Dosi, Nelson et al. 2000, p 4); the literature about technological capabilities subsumes and/or intertwines organisational components in the development, organisation and use of knowledge on hard technology, i.e. processes and artefacts, which are embedded with other resources within firms and systems (e.g., Bell 1984; Lall 1992; Bell and Pavitt 1993; Lall 1993; Lall 1998; Padilla Pérez 2006) as clearly identified by von Tunzelmann (2009).

[115] von Tunzelmann quotes Verona and Ravasi (2003) as one of the relatively rare exceptions. It is a study of a single company in the hearing-aid industry.

The dichotomy of technological and organisational capabilities has already been addressed in the literature of dynamic capabilities in firms (e.g. Leonard Barton 1992; Dutrénit Bielous 1998; Tsekouras 1998) because firms are multi-technologies (Patel and Pavitt 2000) [116] and in systems/regions. Heindenreich (2005, p 739) makes this distinction for the evolution of regional capabilities.

In this research, we refer to technological capabilities for the organisation of specific knowledge, artefacts, operations and processes, products, which are industry- or sector-specific (Malerba 2005). On the other hand, organisational capabilities refer to specific knowledge concerning the specific arrangements in a particular order or structure in which a firm or another type of organisation works.

The distinctness and coevolution of technological and organisational capabilities are also a concern for Nelson and Nelson (2002, p 268). They explain that there are interdependencies in the evolution of social technologies ('ways of organizing activity within particular organizations…and ways of transacting across organizational borders' and physical technologies ('a particular technology is inextricably connected with a particular machinery and other specialised inputs') (Nelson 2003a, p 15). They pursue this differentiation when they explain that physical technologies are concerned with what Adam Smith referred to as the division of labour in his example of pin making, which fits the coevolution of physical technologies (i.e. individuals doing specific activities with specific artefacts), and can be termed *technological capabilities.*[117] In addition, the organisation of work, which inside firms refers to business practices, i.e. social technologies, can be called *organisational or managerial capabilities.*[118]

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[116] Dosi and Teece (1993, p 6-7, cited by Patel and Pavitt, 2000, p 314-315) argue that organisational-economic competencies are distinguished from technical competencies. 'Organisational economic competencies involves 1) allocative competence, deciding what to produce and how to produce; 2) transactional competence, deciding whether to make or buy, and whether to do so alone or in partnership; and 3) administrative competence, how to design organisational structures and policies to enable efficient performance. On the other hand, technical competence includes the ability to develop and design new products and processes, and operate facilities effectively... A firm becomes superior in a particular technological domain because it has certain organisational capabilities: it allocates resources to more promising projects, it harnesses experience from prior projects, it hires and upgrades human resources, it integrates new findings from external sources, it manages a set of problem-solving activities associated with that technology'.

[117] *Italics from the author.*

[118] *Italics from the author.*

At the system level (as well as the firm level) the evolution of capabilities involves changes in organisational and technological routines and institutions that contribute to economic growth (Lundvall 2005). This distinction can also be difficult. However, if the assumption here is that technological and organisational capabilities are distinctive with respect to their knowledge content, what is important, then, is to understand the sources of knowledge (von Tunzelmann 2009a). In other words, it is a priority to understand how firms and organisations bring new knowledge into use either as a practice or as hard technology (product, processes, technologies and artefacts).

Regarding the sources of knowledge, Lundvall (2005) argues that in the development of capabilities, there are two main strategies: R&D strategies, which utilise and create access to the explicit knowledge of Science, Technology and Innovation or STI-mode innovation (i.e. activities of universities, research institutes and possibly R&D departments in firms), which might be more specific to the creation of specific knowledge and use of hard technologies. This can explain a technological capability development of the firm or system. The other mode is with activities based on organisational learning-by-Doing, -Using and -Interacting or DUI-mode innovation. This mode is related to technology transfer and appropriation, which might be better associated with the organisation and distribution of knowledge and technologies. This can be referred to as an organisational capability of the firm or system. However, both modes of innovation are highly complementary ways of explaining the transformation of firms/systems. From here, the relevant processes are the interdependencies of organisations in systems on creating knowledge and organising the distribution and appropriation of this knowledge by users, firms and other organisations to create wealth effectively (Lundvall, Johnson et al. 2002). If research organisations, which might create technological knowledge and technologies, do not have the capabilities for diffusing knowledge (an organisational capability complementary to the capability for creating technological knowledge and technologies) the knowledge created by those organisations will be underutilised or wasted. On the other hand, if users do not have the resources (absorptive capacity) to appropriate technological knowledge, even if the knowledge is available in the regions/systems, and the channels to diffuse it are there, firms will not benefit from it. Therefore, the virtuous learning cycle (coevolution) of intra and inter organisational capabilities in regions may not be created.

Following this line of discussion, what is important, then, is how knowledge is organised and integrated into the firms and organisation and how the interactions of these actors and the integration processes can be observed in a system/region. As von Tunzelmann (2009, p 459) points out, ‘the major differences between each level *(micro-meso-macro)*[119] arise in regard to what can be considered exogenous or endogenous to the system. Thus at the regional level, as distinct from the firm level, the research sub-system may be partly endogenized. The quality and quantity of research output in a region may be in part a reflection of the capabilities of its universities and research institutes, etc.; thus transcending the case for seeing them as just exogenously generated “competencies”’. von Tunzelmann (2009, p 459) stresses the generation ‘in situ’ of knowledge created by the interactions of firms with suppliers of inputs and other regional actors such as consultants and other public and private organisations located in the regions, which may be mainly tacit, without excluding the possibility of having some codified knowledge that can be also included as endogenized in the system/region.

In analysing ‘technological capabilities’, von Tunzelmann (2009) divides this literature into two subsets, one that deals with technological capabilities of firms in advanced industrial countries, and the second with firms’ technological capabilities located, or at least headquartered, in developing countries. He argues that for latecomer firms and their countries, his view is closer to the work of Abramovitz (1986; 1994), who talks about ‘technological congruence’, which hypothesises about how capability development is related to technological and organisational change over historical time. This historical feature is a central point for understanding regional development. For policy makers, it is a starting point for considering how systems of production could be upgraded through intervention. However, von Tunzelmann (2009, p 455) argues that there has been no formal testing of these relationships. This thesis aims to provide some evidence of these relationships.

[119] *Italics from the author.*

3.4.4 Firm learning processes based on interactions with other organisations and the development of dynamic capabilities

The dynamic capabilities literature sets up organisational learning as the core process for understanding organisational routine changes and capabilities evolution (Dosi, Nelson et al. 2000; Zollo and Winter 2002; Winter 2003; Winter 2003a; Helfat, Finkelstein et al. 2007). Zollo and Winter (2002, p 343) proposes an evolutionary process to explain how operating routines in firms change into dynamic capabilities over time through different learning mechanisms. These learning mechanisms are i) the accumulation of experience that represents an accumulation of lessons learnt directly from the enactment of organizational routines; ii) knowledge articulation, consisting of deliberate efforts to articulate and share experiential knowledge developed from the enactment of organisational routines; and iii) knowledge codification, consisting of deliberate efforts to develop artefacts and codes (e.g. manuals, project reports) from the articulated knowledge. This evolutionary process refers to the modification of existing organisational routines (or operating routines) rather than mechanisms directly shaping the development of dynamic capabilities. This means that when changes are introduced (e.g. new machines, new knowledge, new processes, changes in the management, etc.) there are new principles for organising the operating routines or organisational routines and procedures among the different individuals participating in operating routines. Thus individuals may have to learn something new and change their former routines until they reach a certain degree of understanding and success. However, the fact that multiple individuals and interests are involved suggests there might be conflict. Therefore, individuals operating the routines – middle and general managers – may have to reorganise and negotiate ways of carrying out the procedures and new practices in order to alter the previous dynamic capabilities. These processes explain changes in the intra organisational routines that comprise intra organisational capabilities.[120]

Organisational routines accumulate collective understanding (collective learning) about the execution of organisational tasks, which may be tacitly updated and refined to achieve continuous marginal improvements in performance (Zollo and Winter 2002). The term tacit is used in this context to denote knowledge that is rarely explicitly

[120] See Coriat (2000) Fujimoto (2000; 2001) detailed cases of the transformation of organisational routines and capabilities in Japanese car manufacturing firms.

articulated *in practice* and thus remains non-codified. The tacitness of knowledge in this sense makes an exchange of knowledge between individuals within the firms and with other organisations more difficult to codify, but helps to explain both the existence of differences in firm performance and the existence of intermediary organisations that aim to improve the flows of knowledge between firms and other organisations (Johnson, Lorenz et al. 2002).

However, this tacit upgrading is an insufficient basis for understanding capabilities building. Our criticism of this way to explain capabilities evolution is that it focuses mainly on the internal changes in firms/organisations and gives very little attention to interactions with other individual/actors outside the firm and interactions with hard technologies, i.e. artefacts, the inputs and their quality including the organisations' absorptive capacity. It assumes that individuals and their groups within firms are capable of reflecting on what they do and of finding new ways to improve (which is part but not the entire story) because they might master the state of the art in hard technologies, inputs, etc. Individuals know how to extract the rents from them, which in many cases, particularly in economic development contexts, may not always be the case. Individuals may be able to identify knowledge and technological gaps, but be unable to fill them.

On the other hand, considering firm interactions with other organisations is important because they are likely to be an important impetus for learning to address changes in specific knowledge and technologies and routines, which may lead to changes in capabilities and hence again in routines. Organisation and coordination of activities and processes due to interactions, therefore, are the core of intra and inter organisational capabilities evolution. This is in line with von Tunzelmann (2009a) talking about the learning mechanisms for evolution of regional capabilities (pp 14-15), which must be interactive and dynamic. This could be interpreted as co-evolving processes within firms and other organisations in a local space, which explain regional capabilities evolution.

von Tunzelmann (2009, p 458) argues that the 'integration' of dynamic capability is as much social as organizational or technological, and to achieve this requires a succession of intermediate steps, each of which may well lead to some 'creative destruction' in the

Schumpeterian sense. This theoretical discussion is the basis of the evolution of the innovation system regarding capabilities building and institutions (Nelson and Sampat 2001; Nelson and Nelson 2002; Nelson 2003a; Nelson 2003b; Nelson 2005).

3.4.5 Capabilities evolution in systems and regions

While many routines are seen to be internal to the firm, some changes in routines involve interactions between individuals within the firm and individuals in other organisations. These interactions are subject to routinisation processes (Zollo and Winter 2002); which generate repetitive behaviours (i.e. inter organisational routines or inter firm knowledge-sharing routines) and complement capabilities and resources, e.g. formation of alliances (Dyer and Singh 1998; Zollo, Reuer et al. 2002; Dyer, Kale et al. 2004; Zollo and Singh 2004). Knowledge-sharing routines are regular patterns of firm-level interactions that permit the transfer, recombination, or creation of knowledge. To make these processes effective, they need to be institutionalised (Helfat, Finkelstein et al. 2007, p 69). The same principle can be applied when firms interact with other organisations (e.g. universities, research institutes and suppliers of technologies) to exchange information and knowledge through different patterns and processes of learning by interacting (Coriat and Dosi 1998; Coriat and Weinstein 2002) in a local space.

This could be a way of explaining the evolution of regional capabilities put in other words by Cooke (2005, p 1131) ‘networking had become systemic’ and by von Tunzelmann (2009a, p 16) ‘in tune with those of its suppliers and its customers’. Therefore, the organisations involved in the interactions may also change their own capabilities because they could learn from each other’s knowledge needs. However, during interactions, some specific capabilities may emerge which can be accumulated and appropriated by the system/region (inter organisational capabilities), which are distinct from those within firms and organisations and these capabilities must be included in the capabilities of a regional system. However, intra and inter organisational capabilities may or may not coevolve effectively for several reasons such as lack of individuals capabilities and incentives, either within the firms and or/regions.

The co-evolving processes of intra and inter organisational capabilities, which involve intra firms and inter organisational interactions might be seen as one of the foundations of institutional learning in systems of innovation (Lundvall, Johnson et al. 2002; Lundvall 2005).

This line of analysis suggests that when the business and/or economic environment is relatively stable,[121] the exercise/use of current organisational routines and capabilities is sufficient to allow firms to stay in business. However, when conditions in the business and/or economic environment change (e.g. international trade, technological changes, etc.), firms and generally organisations are forced to improve and/or develop new capabilities (or a higher order of capabilities, in the words of Zollo and Winter, 2000 and Winter, 2003), changing their routines to become competitive, because there is a gap between what is desired for the firm and its actual performance (Iansiti and Clark 1994, p 562). The more frequently a capability is used (cumulative processes) the higher the likelihood of improving its effectiveness (Narduzzo, Rocco et al. 2000). However, the rate of accumulation and the nature of the capabilities that result from interactions with other actors in any system (Zollo and Winter 1999; Zollo and Winter 2002) depend on the speed of change in the factors affecting the system's ability to react (Florida and Kenney 2000). In other words, the learning capability of the system by itself would be a dynamic capability of the system to affects its own capabilities. Failures in updating dynamic capabilities within firms *and their systems*[122] will eventually transform firms' *and systems'* core competences[123] (Teece 2000) into core rigidities[124] (Leonard Barton 1992; Leonard Barton 1995; Pavitt 1998), because their routines are engrained in inappropriate patterns of thinking that may impede innovation (Tidd and Bessant 2009, p 72-74). Therefore, deliberate investments of firms and other organisations are required to update or transform their routines and capabilities (Teece and Pisano 1994; Teece, Pisano et al. 1997; Teece 2000) and eventually to affect the capabilities of the

[121] This is not in principle true, since business environment continuously evolves.
[122] *Italics from the author.*
[123] Core competences are 'those competences that define a firm's fundamental business as core. They must accordingly be derived by looking across the range of a firm's (and its competitors') products and services. The value of core competences can be enhanced by combination with appropriate complementary assets. The degree to which a core competence is distinctive depends on how well endowed the firm is relative to its competitors to replicate its competences' (Teece 2000, p 38).
[124] Core rigidities occur 'when individuals and groups with the established competencies for today's products are either ignorant of, or feel threatened by, the growing importance of new competencies' (Leonard Barton 1995, p 445).

system/region (von Tunzelmann 2009a); which is one of the foundations of the innovation system approach and evolutionary economics.

In the processes for changing actors' capabilities in a system, there may be actors resisting change because they do not have sufficient incentive to do so or might believe they would fall behind leaders because of their lower capacities for change. There is also the possibility that systems might neither accumulate knowledge effectively nor learn (Winter 2003; Winter 2003a) and, therefore, might have difficulties in developing capabilities. There may be several reasons for this, including actors' poor absorptive capacity or the underdevelopment of a system's social technologies (Nelson and Nelson 2002) (e.g. organisational capabilities). As a result, a particular system might lag far behind other systems or the system leader (Abramovitz 1999). Such outcomes are described in this thesis as 'dysfunctions', and are applied particularly to the clusters of missed or underdeveloped capabilities identified using a function-base approach explained in the next section (3.5).

In summary, this section has presented an analysis of the literature of dynamic capabilities seeking to provide theoretical bases to identify and understand the evolution of capabilities of the two producer groups in agribusiness (i.e. dairy farmers and dairy processors). This analysis, although important, is not sufficient to explain performance in industrial sectors operating within a regional context. However, the analysis allows us to focus on the coevolution of organisational routines that are seen as some of the building blocks of organisational capabilities in firms (i.e. dynamic capabilities) and/or inter organisational capabilities when we focus on the interactions of firms with other organisations in a region.

This analysis of organisational routines also explains efficiency and/or inefficiency of firms in achieving a specific aim due to the nature of these processes (e.g. specificity of knowledge and families of complementarity routines, agency of the individuals to change the routines, etc.) and their possibility to change ('mutation'). These changes may happen because agents carrying out these routines, might reflect on better ways for improvement, find gaps in what they want to achieve, are forced to change them by recognising external or internal pressures (by managers) or by the introduction of new knowledge and artefacts, which are provided by other organisations.

Thus, the co-evolutionary processes of intra and inter organisational capabilities depend on the ability of firms and organisations to improve and/or renew their routines into improved and new capabilities. These processes are a function of the timing that is required for improved and new assemblages of routines to become, the frequency of the interactions of individuals within organisations and with other organisations (i.e. knowledge diffusion) and their intentionality and agency to change. These interactions may create learning processes within organisations and within the systems/regions (i.e. learning curves). However, differences in absorptive capacity of the firms/organisations can accelerate or delay changes in organisational routines for improving and establishing new capabilities that help to explain shortcomings in the economic performance over time of firms and eventually of systems/regions.

This section also discusses the importance of distinguishing between technological and organisational capabilities and interdependencies to explain their coevolution, which is supported by intra and inter organisational learning. This is important because this research is looking at a specific technological model, which has implications in the development of regional capabilities. The sources of knowledge help us to understand these entities within firms and systems when they are analysed at an aggregated level (e.g. regions). These processes of distinction and later clustering of capabilities (from a micro to meso perspective) contribute and/or are the processes that support functions in systems (i.e. to create and diffuse knowledge), as will be explained in section 3.5. They help us to develop the concept of sector-specific regional capabilities, which will be explained in Chapter 4.

3.5 A function-based approach: Systematic comparison of regional capabilities building for policy making

In order to compare the evolution of regional capabilities and to develop a clear set of policy recommendations for economic sustainability of regions in a specific sector, this research seeks for a systematic approach to delineate a limited number of interactions that support capabilities evolution. In this way, it might be possible to direct the attention of policymakers and private actors to opportunities for intervention and measures of progress in achieving the capacity for sustainable economic growth of regions.

In searching the literature of innovation systems, the assumption here is that the main function of a system of innovation is to create capabilities of the actors to generate, diffuse and utilise knowledge and technologies (e.g. physical artefacts as well as technical and organisational know-how) for innovation processes. Capabilities, then, represent the economic competence of the system to generate economic value (Carlsson, Jacobsson et al. 2002, p 235) and eventually economic growth (Edquist 2005).

For innovation policy development, the innovation system approach has been adopted by regional, national and international organisations to stimulate the processes underlying innovation, industrial transformation and economic growth. However, there are still many problems for developing practical guidelines to set up policy goals using this framework. Furthermore, there is no single way to define and analyse a system of innovation (Carlsson, Jacobsson et al. 2002) because there has not been at present the definition of the determinants of innovation (Chaminade and Edquist 2005). Furthermore, the concept of system of innovation has some problems; it is a static framework, which does not pay enough attention to micro level (Hekkert, Suur et al. 2007). Therefore, there have been many proposals about how to analyse innovation systems in terms of the main processes or functions or activities - also called a function-based approach, functional approach, and functions of systems of innovation - which are carried out by the actors (individuals and organisations) to influence the innovation processes of systems. The main problems with the functional approach is the lack of agreement among scholars of which functions/activities should be included in the framework to assess performance and eventually policy making (Edquist 2005); and the heterogeneity in the use of the approach which has impeded the comparability of these studies and so the approach has been criticised for not providing enough guidelines for policy making (e.g. Bergek, Jacobsson et al. 2008, p 408).

In my opinion, the proposals of functions/activities of systems of innovation to analysing and assessing their performance for policy making have the following problems. First, they are competing frameworks which propose closely related concepts (functions and activities), which are grouped in slightly different ways: specific ten activities (i.e. Chaminade and Edquist 2005; Chaminade and Edquist 2006) or broader processes, i.e. seven functions (e.g., Bergek, Jacobsson et al 2005; Bergek, Jacobsson et al. 2008; Hekkert, Suur et al. 2007). Furthermore, these proposals have been developed and applied aiming different objectives by research groups in developed contexts: a) to provide a rational for public intervention (Chaminade and Edquist 2005; Chaminade and Edquist 2006); b) to provide a multi-level framework for analysing emerging technologies, technological transitions and socio-technical configurations in systems (Jacobsson and Johnson 2000; Jacobsson and Bergek 2004; Bergek, Jacobsson et al. 2005; Hekkert, Harmsen et al. 2007; Hekkert, Suurs et al. 2007; Markard and Truffer 2008), and c) to develop a practical scheme for policymakers to analyzing innovation system dynamics (Bergek, Jacobsson et al. 2005; Bergek, Jacobsson et al. 2008). Second, when researchers look at what functions/activities should be included (see for example Table 3.2) in the framework [125] , whereas many proposals consider some sets of activities and processes as functions none of them have used the same set of processes in a sufficiently systematic way for making an analysis (Bergek, Jacobsson et al. 2008, p 409). The proposal of ten activities has been sought as a way to capture the operation of an innovation system in terms of the role of the government and the interplay between private and public actors to develop specific recommendations on how and when public actors should intervene to improve the overall economic and political process which influence innovation policy (Chaminade and Edquist 2005; Chaminade and Edquist 2006). However, this proposal does not provide empirical application. The proposal of seven-function approach by Bergek, Jacobsson et al. (2005) and Hekkert, Suur et al. (2007) differs in the way of looking at knowledge development and diffusion. Whereas for Bergek, Jacobsson et al. these two processes are seen in the same function in the analysis of innovation systems of sectors; the same two processes are seen separated when the analysis focuses on the dynamism of technological change done by Hekkert, Suur et al. Then, knowledge production focuses on indicators which map out efforts put into R&D projects, patents, investment in R&D and technological performance (i.e. learning curves); and knowledge diffusion is mapping out through networks (learning by using and learning by interacting). Furthermore, knowledge diffusion is seen more specific in the provision of education and training by Chaminade and Edquist.

[125] See the extended comparison of function/activity-based approaches done by Bergek, Jacobsson et al. (2005), Chaminade and Edquist (2005), Hekkert, Suur et al. (2007); Bergek, Jacobsson et al. (2008); Markard and Truffer (2008).

Edquist (2005, p 182) defines activities as ‘the factors that influence the development, diffusion, and use of innovations’... ‘are the same as the determinants of the main function’. By breaking down the operation of an innovation system into ten activities, which are more specific, Chaminade and Edquist (2005) argue that it is easier to translate the complexity of innovation processes into real policy making. However, Markard and Truffer (2008) see activities closely related to micro-level of discrete actors. Since some of these activities are more specific in nature than functions, they do not cover all the aspects of a function (Bergek, Jacobsson et al. 2008, p 410). Furthermore, while functions and activities aim in the same direction, functions fit better the systems concept because activities in a narrow interpretation can only be performed by actors not by institutions or networks. Then, a function-base approach embodies more than the sum of the activities and effects of each of the system’s components (i.e. actors, networks and institutions) a systemic view (Markard and Truffer 2008, p 602).

Another difference in the frameworks is the emphasis that authors give to specific functions. For instance, Hekkert, Suur et al. emphasises entrepreneurial activities as the drivers for innovation and well functioning of the system. On the other hand, Bergek, Jacobsson et al. emphasise entrepreneurial activities in the formation phase of a technological system and the diffusion of knowledge in the growth phase. However, the main problem among the frameworks is that all of them lack of sufficient empirical evidence to build a theory of functions or activities of innovation systems[126].

The agreement of the scholars of functions/activities is that all see systems as having components and/or elements, which interact and have relationships over time. The interactions, however, are seen in slightly different ways. Bergek, Jacobsson et al. see networks as ways for learning, technology transfer and for influencing political agenda, then actor might change deliberately existing institutions or create new ones (a system’s perspective); and Chaminade and Edquist see the institutional set up as affecting learning (an evolutionary perspective). Then, the focus on interactions and learning processes of the functional approach is worth to provide a better way to analyse and assess innovation systems performance.

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[126] This thesis does not attempt to transform the functions/activities in innovation systems into a general theory of innovation. Nor does it enter into the debate regarding which functions, processes or activities are to be included in a function/activity-based approach. This debate is an on-going research process of greater scope than can be addressed in this thesis.

Table 3.2 Functions or activities of innovation systems

Chaminade and Edquist (2005)	Bergek, Jacobsson et al. (2005)	Hekkert, Suur et al. (2007)
Structural components of the system		
Actors Institutional set up affecting learning	Actors Networks for learning, technology transfer and seeking to influence the political agenda Institutions	Actors Networks and relationships Institutions
Functions/activities		
Creating and changing organisations	Entrepreneurial experimentation	Entrepreneurial activities
Provision of R&D	Knowledge development and diffusion	Knowledge development
Provision of education and training		Knowledge diffusion
Articulation of quality requirements from the demand side	Influence on the direction of search	Guidance of the search
Formation of new product markets	Market formation	Market formation
Incubating activities Financing of innovation processes Provision of consultancy processes	Resources mobilisation	Resources mobilisation
Creation/change of institutions	Legitimation	Creation of legitimacy
Networking and interactive learning	Development of positive externalities	
Applications		
Theoretical proposal for policy development	Analysing the dynamics of and functionality of sectoral innovation systems	Theoretical proposal for analysing the dynamics of and functionality of technological change

Source: Modified from Markard and Truffer (2008, p 602).

In pursuing an analytical framework that can be used to analyse a variety of regional innovation systems in a developing context, the aim here is to find a functional approach to help understanding the phenomena under observation, i.e. the regional interactions among the actors that imply learning processes and eventually lead to creation and evolution of capabilities. In other words, to identify and analyse, using functions of innovation systems, the foundations for capabilities building processes. In this way, it is possible to provide a systemic and systematic way of comparing the effectiveness or ineffectiveness of actors interactions to support capabilities building in developing contexts to improve long-term economic performance (Edquist 2005).

In the most simple definition, a system has a function, i.e. it is performing or achieving something (Edquist 2005, p 189) by interactions of the components. The identification and assessments of the functional approach emphasises the importance of what the system does or work in comparison to how is composed (i.e. the structure of the components) (Bergek, Jacobsson et al. 2005). However, structure and functions are intertwined sides of the system and influence each other. But the relationship is ambiguous. Therefore, the way to assess systems is in terms of functions to eventually provide policy recommendations (Markard and Truffer 2008), when using the same set of functions consistently and systematically.

A ‘function’ refers to a technical system, with ‘hard’ system components filling different technical functions, thereby contributing to the system’s overall functionality. Function is also the ‘contribution of a component or a set of components to the overall goal’ *of a system*[127] (Bergek, Jacobsson et al. 2005, p 2 and 8). A function-based approach focuses on analysis of the structural components (i.e. actors, networks and institutions)[128] and their dynamics of an innovation system. Bergek, Jacobsson et al. (2008, p 408) define it as

> ‘a systematic step-by-step approach for analyzing innovation systems, describing and assessing performance and identifying key policy issues...’

> ‘...a framework that not only captures the structural characteristics and dynamics of an innovation system, but also the dynamics of a number of key processes, here labelled ‘functions’, that directly influence the development, diffusion and use of a new technology and, thus, the performance of the innovation system’.

Using a function-based approach (a meso level approach), the analysis of systems has a process focus (instead of a static analysis) and pays sufficient attention to firms and organisations because is firmly rooted in the micro level (Bergek, Hekkert et al. 2006; Bergek, Hekkert et al. 2008). The framework bridges innovation systems thinking with that of management and in doing so, it provides the former with a strong micro level foundation and the latter with the necessary meso level linkages (Hekkert, Suurs et al. 2007). By identifying the key processes in both structural and functional terms, and explaining the strength of these, it is possible to formulate strategies and policies (Bergek, Hekkert et al. 2008), which have the possibility of influencing the

[127] The authors’ remark on the concept of ‘functions’ without any reference to the sociological concepts of ‘functionalism’ and ‘functional analysis’. Thus, the ‘overall function’ is analytically defined and does not imply that actors exist for the purpose of serving that function or are directed by it (Bergek, Jacobsson et al. 2008, p 8).

[128] For this research: *Actors* include not only firms along the whole value chain (including those up- and downstream), universities and research institutes, but also public bodies, influential interest organizations (e.g. industry associations and non-commercial organizations), venture capitalists, organisations deciding on standards, etc. *Networks* are for learning, technology transfer and seeking to influence the political agenda. *Institutions* are the culture, norms and regulations (from Bergek, Jacobsson et al. 2008).

development, diffusion and use of knowledge and technologies as well as the overall function of the system (Bergek, Jacobsson et al. 2008, p 9). In particular, it focuses on overcoming some of the market limitations and system failure approaches.[129] That is, a failure of the total system without specific regard to its elements since a loose use of the system failure would also influence failures in elements of the system (such as functions). For instance, failure in actors' capabilities regarding firms' lack of capabilities to adapt to new technologies in new technological paradigms, i.e. a learning failure, which is especially important in SMEs (Klein Woolthuis, Lankhuizen et al. 2005, pp 611 and 614); and also in the regeneration and renewal of regions (Cooke 2005; Heidenreich 2005; von Tunzelmann 2009a).

Thus, functions are processes or bundles of activities, in a broader sense are emergent properties of the interactions between actors and institutions (Markard and Truffer 2008, p 597), which are helpful in analysing the dynamics of a system as well as analysing activities of the actors in the system (Hekkert, Suurs et al. 2007; Bergek, Jacobsson et al. 2008) to build capabilities. Therefore, interactions again are the main structural processes of the systems that should be studied, as several other authors in function-based approaches (Lundvall, Johnson et al. 2002; Jacobsson and Bergek 2004; Bergek, Jacobsson et al. 2005; Jacobsson and Bergek 2006; Hekkert, Suurs et al. 2007; Bergek, Jacobsson et al. 2008), and regional systems and regional capabilities approaches (e.g., Gertler 2003; Asheim and Gertler 2005; von Tunzelmann 2009a) have repeatedly pointed out.

In this research, there are three main reasons for adopting the functional approach (Hekkert, Suur et al. 2007). First, it makes comparisons more feasible in terms of performance. Second, it permits a more systematic method of analysing the determinants of innovation by drawing maps of functional patterns of actors over time. Therefore, systems performance may be assessed in terms of functionality[130] (*and/or dysfunctionality*[131]) – in other words, how well the functions are served by the factors

[129] System failure also refers to a system that fails to develop or which does so in a stunted fashion (Carlsson and Jacobsson 1997). This is also referred in the literature as a systemic failures or problems (Chaminade and Edquist 2005; Chaminade and Edquist 2006) in the development and implementation of policies.

[130] Functionality refers to the degree of achievement of the seven functions proposed in the analytical framework (Jacobsson and Bergek 2006).

[131] *Italics are author's proposal.*

influencing such performance (Bergek, Jacobsson et al. 2008) considering the differences of the sector depending on their particular stage of evolution in an industry and in the region (Hekkert, Suurs et al. 2007, p 420) and the markets they serve. Third, it has the potential to deliver a clear set of regional policy recommendations.

This is a very important factor for policy making specially in developing contexts because the key function of government intervention is to establish and maintain the institutional arrangements conducive to the efficiency of the economy, i.e. the creation of economic competences and their adaptation to changing circumstances, which might need institutional changes and policies to affect the development of systems capabilities (Lundvall, Johnson et al. 2002). These capabilities might include supporting entrepreneurial activities and regulating selection mechanisms (i.e. markets and competition, antitrust legislation, access to markets, foreign trade, etc.) (Carlsson and Stankiewicz 1991).

In assessing systems performance using a function-based approach in emerging technologies and technological transitions in systems, the focus will be in the generation and diffusion of knowledge; whereas in mature systems and technologies, the main focus should be on the diffusion rates of existing knowledge and technologies (e.g., the creation of improved and new products processes) and the market shares and expansion.[132] However, there is still lack of agreement of what will be the indicators especially at the system level (Carlsson, Jacobsson et al. 2002). Carlsson and Jacobsson et al. (2002) emphasise the need for further research, which distinguishes different units of analysis, the micro and the system levels.

A seven-function approach has been employed in developing countries to analyse catching up processes in specific sectors: the steel and aircraft industries in Brazil, the machinery industry in Korea and salmon farming in Chile (Jacobsson and Bergek 2006). Specifically, Jacobsson and Bergek carry out an integrated and understandable analysis of the successful processes for the creation and accumulation of capabilities. They found that these processes of capabilities' formations are particularly important for developing countries in the cases of resource-based industries. In the analysed sectors, resources

[132] This research proposes a set of specific indicators for the micro and meso levels (see Table 4.7 and 4.8).

were created as a result of selective intervention of the governments in the innovation system aiming at the pursuit of high-level capabilities. They argue that as there are significant up-front costs involved in building up these capabilities, government organisations have intervened for enabling long-term capabilities development, which play a catalytic role in opening up new business opportunities and reveal the early formation of capabilities, more generally, the knowledge formation associated with capabilities. They further argue that

> ‘capabilities are the least definable kinds of productive resources. They are in large measure a by-product of past activities, but what matters *at any point in time is the range of future activities, which they make possible.*[133] What gives this question its salience is the possibility of shaping capabilities and especially of configuring clusters of capabilities, in an attempt to make some preparation for future events, which, though not predictable, may … be imagined’ (Jacobsson and Bergek 2006, pp 701-702, citing Loasby 1998, p 144).

In the developing contexts studied by Jacobsson and Bergek (2006), the seven functions that explain the dynamics of the evolution of capabilities in the innovation systems are:

Creating and diffusing knowledge. This is the core of an innovation system. It entails the breadth and depth (scope and scale) of the system’s knowledge base and how knowledge is created, combined and diffused by the actors within the system.
Driving the direction of search. This refers to the firm’s and organisation’s abilities to identify new opportunities and to assess and justify the incentives and investments underlying them. This requires coordination of effort (i.e. resources and complementary services and knowledge) to lead the innovation process in the system (e.g. articulation of the demand, regulations development, search for investment, etc).
Entrepreneurial experimentation. This refers to the way many entrepreneurial experiments take place. These experiments are triggering factors (e.g. abundance of skilled labour, unique university research, competences in specific or related industries, abundance of resources, geographic advantages, etc.) that operate within a system. However, they will occur only if there are entrepreneurs to conduct the experiments,

[133] Italics of Jacobsson and Bergek (2006, p 702).

search into uncertain markets and technologies and challenge institutions, which are the basis of technological and industrial development. These entrepreneurial experiments imply a continuous probing into new technologies and applications, and a social learning process that unfolds through the course of these experiments at the heart of the innovation system. In the absence of innovative and active experimentation, systems will stagnate (i.e. in the case of mature technologies) and, indeed, without initial experiments (i.e. in the case of new technologies), they will not be formed. Along this experimentation, a learning process and a knowledge formation process occur, which implies a more applied stage than addressed by the first function.

Facilitating market formation. This function refers to the identification and assessment of the existence of the market and articulation of demand including prices, costs, technologies in use, standards, etc. Institutional change, e.g. the formation of standards, is often a prerequisite for markets to evolve, as is the availability of complementary products and services. Market development evolves through a series of phases which might include the emergence of new actors, the exit of inefficient ones and the achievement of a mass market or in some cases, the emergence of niche markets.

Legitimation. This function implies social acceptance and compliance with relevant institutions. In traditional technologies and sectors, it is considered appropriate and desirable for the actors to mobilise resources (e.g. to update the technologies) and to acquire political strength (e.g. to build up new sets of institutions and networks), especially in sectors that are highly politicised (which is the case of the MDS). Legitimacy also influences actors' expectations and, by implication, their strategies. In this way, legitimation influences the direction of search. Legitimation is a precedent for the formation of new industries and their associated institutional set ups. It could also be the precedent for the advance of a technological package. The formation of advocacy coalitions with a shared vision and the objective of shaping institutional arrangements is a key characteristic of the process of structural change that leads this function. In other words, legitimation is the prevailing practice,[134] i.e. the cognitive process in social science for opinion formation.

Mobilising resources. The evolution (and upgrading) of any system requires different types of resources (e.g. technologies, scientific, financial, knowledge, human resources etc.). Therefore, the extent to which an innovation system is able to mobilise these

[134] I.e. organisational routines or social technologies, some of them institutions, according to Nelson and Nelson (2002).

resources and complementary assets from different actors and create the networks and institutions to deal with these transactions, constitutes one of the main mechanisms to observe and discuss in the upgrading of technologies among small producers.

Developing positive externalities. As markets evolve, so too do system functions and they strengthen or weaken the system. Structural change is central in this process. In new technologies, the arrival of new firms may resolve at least some of the uncertainties regarding new technologies and legitimate new IS and markets. This could have a positive influence on four functions: ‘resource mobilization’, ‘influence of the direction of search’, ‘market formation’, and ‘entrepreneurial experimentation’. Therefore, new entrants and/or the strengthening of firms and markets may confer further externalities, such as development of pooled labour markets, emergence of specialised intermediate goods providers, and information ‘spillovers’ benefiting other members in the innovation system or attracting new firms and assets to evolve and enlarge the system. Therefore, this function indicates the overall dynamics of the system and reflects the strength of the collective dimension of the innovation and diffusion processes because externalities magnify the strength of other functions (Bergek, Jacobsson et al. 2008).

In an attempt to provide qualitative and quantitative measures using the seven-function approach, Bergek, Jacobsson, et al. (2005) propose the following indicators summarised in Table 3.3.

Table 3.3 Some indicators of functions in innovation systems

Functions	Some indicators
Creating and diffusing knowledge	Bibliometrics, citations, patents, volume of publications, number, size and orientation of R&D projects, learning curves, etc.
Driving the direction of search	Belief in growth potential, setting up of vision, incentives from factor/product prices, e.g. taxes and prices in the energy sector, the extent of regulatory pressures, e.g. regulations on minimum levels of adoption, the articulation of interest by leading customers, etc.
Entrepreneurial experimentation	Number of new entrants and diversifying established firms, number of different types of applications, the breadth of technologies used and the character of the complementary technologies employed, etc.
Facilitating market formation	Assessment of market size, customer groups, and time frames, designing of standards, purchasing processes, and lead users, etc.
Legitimation	Development of lobbying groups, development of new legislations and standards, etc.
Mobilising resources	Volume of capital, volume of venture capital, volume and quality of human resources, complementary assets (e.g. services, infrastructure, etc.)
Developing positive externalities	Political power, legitimacy, resolution of uncertainties, pooled labour market, specialised intermediates, information and knowledge flows, combinatorial opportunities, etc.

Source: Bergek, Jacobsson, et al. (2005).

As was noted by the proponents of the functions/activities approach, analyses of different functions/activities are intertwined. If one of the functions changes, this can provoke changes in others (Bergek and Jacobsson 2003). On the other hand, the existence of functions does not imply that all functions are planned and carried out in all systems (Edquist 2005). Nevertheless, the approach provides a systemic and systematic analysis of functional patterns for innovations. Thus, what is achieved *(or not achieved)* in the system is in part a result of the internal dynamics of the innovation system, i.e. a chain reaction of positive/negative feedback loops, which might involve all the system interactions (Jacobsson and Bergek 2006, 694-695). These interactions may set a process defined as Myrdal's cumulative causation process[135] (Jacobsson and Bergek 2006, citing Knapp 1999). Myrdal's process of cumulative causation is hard to predict, but possible to follow in real time, if adequate capabilities are in place (Jacobsson and Bergek 2004). However, actors might not achieve what they want, which constitutes a *dysfunction* in the system. Furthermore, other factors also influence internal dynamics. Those factors, also called blocking mechanisms and constraints[136], may constrain or endanger the evolution of the system. These blocking mechanisms refer mainly to structural system weaknesses, which can be of different types (Jacobsson 2005), including: a) market weaknesses (e.g. poor user competences[137]); b) network weaknesses (e.g. poor weak advocacy coalition); and c) institutional weaknesses (e.g. poor development of industrial and product standards in the system).

Empirical analyses of these functions in innovation systems may not only improve our understanding of the dynamics of systems but also provide policy makers with specifications of what has not been achieved (i.e. dysfunctions in systems). It allows the formulation of policies directed at having a specific effect on a particular function or group of functions and it implies that system weaknesses can be expressed in functional terms. For instance, a system weakness may be a lack of sufficient efforts to lead entrepreneurial experiments for the formation of new supporting industries or lack of

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[135] Cumulative causation is defined as when each characteristic (i.e. function) is reinforced by and reinforces each of the others generating cumulative or relative advantages or disadvantages for the whole society (i.e. system) (Knapp 1999, p 85).

[136] Constraints in the systems are those factors associated with socio-economic and cultural issues that cannot be changed by just one of the actors but requires collective action in order to mobilise the resources and knowledge needed to develop the capabilities to overcome them (Jacobsson 2005).

[137] User competences or users capabilities are better analysed in von Tunzelmann (2009 and 2009a) when he discusses the differences in competences and capabilities and how the consumer's capabilities (the last consumer in a value chain) might affect the capabilities of the producer.

resources to support the creation of knowledge through R&D and training programmes. Thus, policy makers should focus on improving functions, not market failures for systems development, as the developers of the framework claim (Jacobsson and Bergek 2006; Bergek, Jacobsson et al. 2008). Complementarily, Cooke and Memedovics (2003; 2006) argue that there are three key policy areas for government intervention: the first is to develop and strengthen current capabilities and/or the creation of new ones. To do so, policy makers have to identify accurately current capabilities and understand the institutional settings that have promoted their development. Second, to design a policy coherent with global competition and the innovation needs of firms (i.e. demand side) and the innovation support (i.e. supply side) of other development organisations. Third, based on the two previous areas of analysis, to plan and design the means of intervention and the degree to which intervention policy must be localised or whether inter-regional national and/or global cooperation would be needed and/or possible.

For the purpose of this research, a seven-function approach offers a complementary ‘organisation’ for the analysis of actors’ interactions, i.e. networks and the effect of the institutions in capabilities building (Bergek, Jacobsson et al. 2005; Jacobsson and Bergek 2006). It also helps to understand the integration of the micro-meso levels with macro level or national policy level decisions. Specifically, this can be done when the analysis maps out the processes and mechanisms that focus on the interactive learning processes those actors collectively carried out in specific locations (network for learning) under specific institutions. Thus, differences and commonalities are identified, and they can be used as a foundation for more general or overarching (i.e. meso-macro level) interventions.

In summary, this subsection links the analysis of systems’ functions to the rationale for public intervention (Chaminade and Edquist 2005; Chaminade and Edquist 2006) that guides policy making in several areas, e.g. setting up benchmark technologies in sectoral systems (Jacobsson and Bergek 2004); guiding policy makers intervening in catching up countries (Jacobsson and Bergek 2006; Bergek, Jacobsson et al. 2008); observing and assessing technological change (Hekkert, Harmsen et al. 2007; Hekkert, Suurs et al. 2007); and improving policy making (Cooke and Memedovic 2003; Cooke and Memedovic 2006). This analysis helped to identify a seven-function approach that will be used to assessing capabilities development that contributes to economic growth in regional systems. Testing this analytical tool could further advance the debate concerning how to balance regional economic disparity with high-level or national policy making, which may be adapted to treat different regions in different ways.

3.6 Summary

The core of this chapter is a discussion of the theoretical bases for elaboration of a concept and an analytical framework to indentify and analyse regional capabilities. This chapter has set up in section 3.1 the main empirical issues, which guide the literature review regarding the technological and organisational processes that define the capabilities changes in regions in the MDS. From these insights, we have chosen and reviewed the literature of the RIS and regional capabilities approaches, SIS approach, dynamic capabilities, and a function-based approach.

In seeking to explain regional capabilities, in section 3.2 we draw from RIS approaches a) the importance of localised learning, regions being better units of analysis than countries, with co-location of actors and complementary assets, which help the creation and flow of tacit and codified knowledge; b) the understanding of the interplay and alignment of the meso and macro levels of institutions for economic progress; and c) the importance of the regional structure in identifying interactions and inter relationships which are important to mobilise resources for knowledge creation and learning.

However, there have not been satisfactory explanations on how the creation and flow of tacit and codified knowledge is carried through interactions of regional actors that build capabilities. The regional capabilities approach explores further the interactions for start up, regeneration and renewing of regions. This literature acknowledges that regional capabilities building processes imply changes in the old routines with new ones (von Tunzelmann 2009a). These changes involve learning processes, through regional interactions as well as global-local interactions and networks to overcome the difficulties of firms and/or research organisations in updating their capabilities (Cooke 2005) and/or renewing traditional industries and regions facing institutional changes. Additionally, in section 3.3, the SIS approach expands our understanding of the differences within sectors in terms of knowledge base (i.e. approapriability and cumulativeness), the actors and their interactions with institutions, which influence innovation processes (Carlsson and Jacobson 1997; Malerba 2002; Malerba 2004).

In section 3.4, we search the dynamic capabilities literature, which provides an understanding of intra and inter organisational learning processes altering organisational routines and eventually capabilities, which are also influenced by external sources of knowledge coming from other actors. Since the sources of knowledge are different and might contribute to specific capabilities evolution such as technological and organisational, a theoretical distinction and the importance of their coevolution also become relevant in the identification and analysis of capabilities in firms and eventually in systems/regions. This search of the dynamic capabilities approach brings together theoretical elements for understanding capabilities in firms and their micro processes, organisational routines, which change through interactive learning processes within the firms and between firms and other organisations. The extent of change of these firms' capabilities is influenced by the capabilities of suppliers, consumers and other actors in a system. In turn, the capabilities of these other actors are also influenced by the capabilities of firms. Then a co-evolutionary process takes place if alignments of aims and coordination processes occur among these actors. The ultimate result is that coevolution of the capabilities of these actors may influence the economic performance of the sectors in a local space.

Finally, in order to make a systemic and systematic comparison of the capabilities creation and accumulation in regions, a function-based approach was analysed. This literature helps to understand that functions are grounded or founded in intra and inter organisational capabilities, or at least the *changes* in these functions are grounded in *capabilities building processes*, which support the growth of firms/organisations and systems/regions. Therefore, capabilities facilitate (or are helpful in) and are necessary conditions for the well functioning of a system. For instance, firms using consultancy and other professional services (i.e. technology suppliers that sell capital goods, technology and market services) are indicators that capabilities evolve to address users' needs. Therefore, these capabilities are, in turn, helpful in the system's function of 'creating and diffusing knowledge'. However, other channels may serve the same function, e.g. public organisations providing training programmes, public education in universities, etc. 'Measures' of the direct impact of these capabilities are not easy to obtain or observe. Nonetheless, capabilities may determine catching up processes (Jacobsson and Bergek 2006) and adequate capabilities provide a basis for functions, and combinations of functions influence systems performance (Carlsson, Jacobsson et al. 2002; Niosi 2002). The development of regional policies (Cooke and Memedovic 2003; Cooke and Memedovic 2006; Bergek, Jacobsson et al. 2008) to address the future sustainability of systems/regions should take into account the timing and costs involved in building capabilities. Thus, policy making organisations must think in terms of enabling the long-term development of capabilities.

In Chapter 4, we will develop the concept of sector-specific regional capabilities and an analytical framework, which draw from some specific aspects of the approaches of RIS, regional capabilities, SIS, dynamic capabilities and functions systems. The potential value of the concept and its analytical framework is that it draws attention to the inputs, processes and outputs of capabilities building processes, including the dysfunctional aspects and weaknesses, and overcomes the limits of not having an integrated way of identifying and analysing regional capabilities and the processes/mechanisms which support their evolution. By using an analytical framework comparing three regions, this thesis attempts to provide an integrated micro-meso level way of analysing regional capabilities in agribusiness and to improve policy making aimed at supporting economic sustainability of the sectors in the regions.

Chapter 4. Sector-specific regional capabilities: Analytical framework and research method

After introducing the research topic and questions in Chapter 1, Chapter 2 established the context of the MDS after NAFTA. Chapter 3 introduced the main theoretical approaches for understanding how capabilities might evolve because of interactions of firms and other organisations in a region. Of particular note were the micro processes (i.e. organisational routines) by which intra and inter firm capabilities coevolve. These, it was argued, were sector-specific and within regional structures, the interactions between actors and institutional arrangements support the learning underlying the capability-development processes. For purposes of policy analysis, it was argued that capabilities should be considered as functions in system.

This chapter makes operational the theoretical discussion of the preceding chapter in a way that facilitates empirical investigation on how capabilities evolve in dairy regions. In making the theory operational, it is necessary to identify those capabilities that will be empirically investigated, they are three groups: a) milk production and commercialisation; b) dairy processing and market development; and c) dairy regional development, which for this research constitute regional capabilities. Other capabilities can also be relevant in the analysis of regions, e.g. capital good suppliers' capabilities, final consumers' capabilities, and some other intermediate goods and service providers such as financial organisations and research organisations, which are not studied, but the research provides some examples. However, the reason to focus on these three groups is that they are the results of the principal actors' interactions responsible for the improvement of productivity and competitiveness in the Mexican dairy regions and eventually of the MDS. While the potential of the regions to improve productivity and competitiveness may be limited by the capabilities of those actors that are not examined, it would certainly not be possible to improve competitiveness and productivity without addressing each of the capabilities groups examined in this research.

The reason for taking specific theoretical elements or foundations from the reviewed approaches (i.e. intra and inter organisational routines evolution for capabilities building, processes for the production and exchange of tacit and codified knowledge, organisational and institutional learning, and assessment of actors interactions for capabilities building and improvement of policy making) is that they help us to understand the complexity of the actors' interactions and processes in building capabilities and the consequences of doing so.

To operationalise these theoretical elements, this research develops the concept of sector-specific regional capabilities and an analytical framework to guide and integrate the identification and analysis of regional capabilities at two levels: a micro level and a meso level. In so doing, it is possible to observe multilevel processes and interactions of firms and organisations in a region and to make a systemic and systematic comparison of the capabilities and performance over time in the Mexican dairy regions during the period since NAFTA. At the micro-level the focus is on dairy farms and firms' interactions that have led to collective learning (e.g. collective activities/processes/mechanism) and that trigger the changes of intra organisational capabilities, including technological and organisational routines for milk and dairy production and commercialisation. At the meso level the focus is again on collective interactions for regional development of dairy farmers and firms' interactions with other organisations, which led also the intra organisational capabilities and changes of inter organisational capabilities in regions, such as production capabilities, alliance-making capabilities and research capabilities.

The concept and its analytical framework will be used to identify and analyse the evolution of capabilities in three dairy regions in Chapter 5 and, in Chapter 6 we will make a comparative assessment, introducing other factors that might have impeded learning processes or delayed capabilities building. In Chapter 7, we will draw conclusions about past and potential future policies using a 'function-based approach'.

This chapter is organised into six sections. Section 4.1 links the motivation of the research to the need to develop a concept to define regional capabilities and an analytical framework to identify and analyse them.

Section 4.2 develops the concept of sector-specific regional capabilities and its analytical framework based on the elements identified in the reviewed literature and how these contribute to the literature on evolutionary economics.

Section 4.3 describes why a multiple-case study research method was chosen to explore the micro-meso level of capabilities building processes. It also explains how the cross-case analysis of the three dairy regions is employed following the methodological suggestions of Yin (2003a, 2003b) and Eisenhardt (1989) to provide evidence for the capabilities building processes in regions. Subsection 4.3.1 justifies the selection of the regions to provide the evidence and subsection 4.3.2 explains the analytical strategy to be applied for the development of the cases and the analysis of the regional capabilities.

Section 4.4 explains how the analytical framework is operationalised, i.e. how it is used to identify and analyse the development of capabilities in dairy regions. It has five subsections. The first explains how to identify the structural components (i.e. actors, networks and institutions). The second explains how the micro-meso level analysis of interactions will be carried out to explain changes of organisational routines (and procedures) into capabilities in firms. The third explains the meso level analysis of how capabilities contribute to functions and dysfunctions in regions. The fourth explains the actors' blocking mechanisms for capabilities building. The fifth explains how capabilities contribute to functions, helping us to identify policy recommendations for improving capabilities building aimed at the economic sustainability of each region.

Section 4.5 explains the scope of the research and identifies some of the constraints encountered in constructing the case studies. Finally, section 4.6 summarises the chapter.

4.1 Linking the motivation for this research to the development of a sector-specific regional capabilities concept and an analytical framework

This section explains the motivation for developing the idea of 'sector-specific regional capabilities' rather than relying on alternative frameworks which would direct attention to individual firms or to more general regional features. By developing the concept and its analytical framework, it is possible to identify and analyse the changes of regional capabilities due to the interactions of dairy farmers and firms and the interactions of these firms with other organisations and to indicate how these changes have supported the economic growth of the regions after NAFTA.

Regional capabilities development and accumulation offers an alternative to the neoclassical economic theory of market failure. Instead of a problem in an incentive structure (neoclassical theory), an evolutionary explanation of performance focuses on systemic successes and failures, either as the result of success or failure in creating capabilities, which affect the performance of regions.

The complementarity features of capabilities in regions mean that having strong capabilities in one area may not have very much effect on performance if capabilities in another (complementary) area are weak. It is therefore important to asses the interdependence of capabilities. This interdependence can be assessed in terms of coherence or incoherence (alignment or misalignment) of actors and may be assessed by examining how actors collectively achieved or failed to achieve advances after NAFTA. [138] Advance as assessed in this thesis is defined as improvements in productivity and competitiveness of a collection of actors in a geographical region relative to the average performance of such regions across the nation.

This thesis claims that the advance of Mexican dairy regions is limited, at present, by difficulties in integrating multiple systems of milk and dairy production. This is especially true in some regions where the structure of production is scattered among small producers, who still have productivity problems on their farms and a lack of full infrastructure for chilling milk and organising the production and commercialisation of milk, stemming from their historical development and local patterns of milk and dairy production capabilities. Nevertheless, even in these regions, an alternative pattern or ‘configuration’ of capabilities development in milk and dairy production might possibly be viable (e.g. artisan cheese and local dairy products) using milk which is neither chilled nor pasteurised. While this thesis identifies this possibility, it does not assess its feasibility.

[138] It may be true that functional and dysfunctional patterns can be assessed at more detailed levels, e.g. at the level of the interactions between specific firms or other actors; but this would require either the sacrifice of a broader comparative view of important regions or a much more extensive programme of research than could be undertaken by a single researcher in a limited time period and with limited resources.

The importance of studying the changes in capabilities of the Mexican dairy regions is that whereas some positive developments[139] have had a major impact on agribusiness, there have also been some setbacks to milk production for small farmers. Their displacement from the regions has become a matter for social and political concern. The aim of this thesis is not to focus, however, on the issues surrounding the displacement of small farmers; they might eventually have left the system for other reasons that are beyond the scope of this thesis.[140] Instead, the aim is to focus on understanding the development of capabilities to support economic sustainability of the dairy regions in the long term, which requires insights into the patterns of capabilities evolutions observed in different regions.

It is important to note that this comparative regional assessment involves more than an assessment of progress in the performance of individual actors. The dominant technological paradigm, the specialised milk production system, is highly dependent upon the reliable supply of chilled milk. Such a supply is the result of a collective development of individual actors in a coordinated way. To make the transition to this specialised system it might be possible for dairy firms (the milk processors) to impose requirements on farmers. However, this action would have major disruptive effects on individual farmers, particularly those with smaller businesses, because of the variety and complexity of knowledge required to change their old routines and procedures. In other words, to promote the development of regional capabilities might be a better way of disentangling and promoting the processes of long-term growth rather than expecting the market to sort out the most efficient producers through competition, leaving those unable to compete to fend for themselves.

To answer the research questions it is necessary to identify specific capabilities and processes in the value chain, which have contributed in developing reliable supplies of high quality milk for dairy production. This has entailed several changes in the routines and procedures of technological components and processes employed (see Tables 2.3 and 2.6, Chapter 2) to increase and improve the production of milk and dairy products,

[139] For example, increase in the supply of cheaper inputs for dairy production, increase in the variety of dairy products for more sophisticated markets, and increase in the availability of technologies for the modernisation of the regional systems (see Lala and Sigma Alimentos capabilities development in sections 5.1 and 5.2).

[140] For example, economic transformation may encourage new patterns of agricultural specialisation or provide new opportunities for paid employment that cause smaller producers to exit from the MDS.

each of which involve the integrated efforts of both farmers and dairy processors. Thus, changes and coevolution in both the technological and organisational capabilities of farmers and dairy processors (i.e. the physical and social technologies following Nelson 2005, pp 195-209) are needed to improve the overall regional capabilities for milk and dairy production and dairy regional development.

In order to make these improvements and thereby modernise the system of milk and dairy production, *incremental innovations* are necessary. Modernisation of milk production (or incremental innovation) is taken as an 'orienting' or defining principle impelling development towards the specialised milk production system, a specific technological model, and the development of new dairy products (see sections 2.4 and 2.5). The degree to which the specialised milk production system became a central focus of this thesis is the consequence of results that emerged from the research. 'Progress towards the specialised milk system' became the most relevant means of describing the changes in the period studied and helped to simplify and organise the evidence.

Modernisation using this technological model, nevertheless, has bias and has been perceived as a fairly coercive way of improving capabilities, especially in small farmers, which has created some contention among dairy farmers and firms in some of the regions (see Los Altos and Tabasco) through the imposition of the model by dairy processors, supported by some government organisations (Rodríguez Gómez and Alvarez Macías 1998; Rodríguez Gómez 1998a; Cervantes Escoto, Alvarez Macías et al. 2001; Alvarez Macías 2005; Castañeda Martínez 2005; Cervantes Escoto 2005). Furthermore, it might create long-term problems regarding the overuse of water and creation of pollution in La Laguna and erosion of land in Tabasco. However, these aspects are not covered in this research.

In conducting a comparative regional innovation study focusing on a specific sector in other contexts, there might be more than one set of organising principles and therefore competing and alternative configurations of capabilities and more than one way of seeing and grouping capabilities into functions. In the present case, these incremental improvements increased productivity within farms (e.g. cows' milk yields) and improved the quality of milk. Because of higher volumes of milk with better quality becoming available, dairy processors were able to increase production, to improve the quality of their products and to produce new dairy products. These changes appear to have contributed to the economic sustainability of the systems that made them.

As we will see, although change was incremental, it was also relatively continuous. One reason for this appears to be that farms and dairy firms were supported by other firms and non-profit organisations, including government agencies, which shared a ‘modernisation’ agenda. It important to note the role of specific actors in overcoming inertia produced by actors resistance to disruption who attempt to preserve system stability[141] (Miller 1999). One way of overcoming inertia is to increase collaboration between actors, for example, farmers working together with dairy processors to improve the quality of milk. Another example is government agencies working together with farmers to eliminate barriers to the formation of farmer groups collectively delivering high quality chilled milk as the result of introducing new milking and chilling systems. The relative importance of these (and other) methods for overcoming inertia, as well as remedying other possible blockages or constraints is to pursue economic sustainability.

Since the capabilities of regional actors and supporting organisations coevolve, the networks and the collective learning promoted by specific institutions (e.g. milk quality and common adoption of best practices in milk production systems) could have been restricted by other factors. The identification of these factors or constraints that impede or delay capabilities building, or produce system dysfunctions also become a basis for policy making that might address policies or market interventions to promote better functionality and/or eliminate factors that make the system dysfunctional.

4.2 Development of the concept of sector-specific regional capabilities and an analytical framework

In this section, we draw from the literature discussion in Chapter 3 some foundations to build up the concept and its analytical framework because as discussed before, the existing literature does not offer better specifications for identifying and analysing capabilities in agribusiness.

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[141] Stability here is the homeostatic phenomenon observed in environmental systems.

This research operationalises the proposal of regional capabilities from von Tunzelmann (2009a) and Cooke (2005) by proposing a concept and an analytical framework. They help identifying and analysing how the technological components, procedures and routines of firms changed overtime and how those changes were influenced by other organisations in regions. This research identifies the interactions (collective activities, processes and mechanisms) between these organisations. From these interactions, it is possible to infer that when individuals in firms interacted with other individuals from other organisations, some of these interactions created intra and inter organisational learning processes, which affected the organisational routines and led changes in the intra and inter organisational capabilities of regions. It does so, by analysing and comparing systematically the changes in regional capabilities of three regions by using a seven-function approach. In this way, it is possible to infer that those changes in capabilities led the economic output of the region; and helps developing regional policies aiming to improve capabilities building in firms and to change institutions to support the development of capabilities.

To summarise, theoretically and empirically, there have been many attempts to explain regional economic growth based on the evolution of innovation changes in firms and their regional institutions (e.g., Asheim and Isaksen 1997; Braczyk, Heidenreich et al. 1998; Cooke, Heidenreich et al. 2004; Asheim and Coenen 2005) and possibly many more attempts to study the development of capabilities in firms (e.g., Dosi, Nelson et al. 2000; Helfat, Finkelstein et al. 2007). However, very few have attempted to integrate the micro and meso levels, i.e. regional capabilities (e.g., Cooke 2005; Heidenreich 2005; Padilla Pérez 2006; von Tunzelmann 2009a).

With the regional capabilities approach, von Tunzelmann (2009a) proposes to integrate micro and meso levels based on the changes of traditional routines; for which capabilities of producers have to be in tune with the capabilities of suppliers of inputs, knowledge and technologies, in a region. In this way, these capabilities are interactive and dynamic. Additionally, Cooke (2005) proposes that local-global interactions are also important to update regional capabilities. In this way, it is possible to explain how innovation and production actually function in regions. Capable actors acquire and transform knowledge from implicit to explicit locally (Cooke 2005, p 1147) using different internal and external sources of knowledge (different laboratories in the words of von Tunzelmann 2009a, p 15), which create intra and inter organisational learning. These processes are affected by regional and national (and possibly global) institutions. Organisational and institutional learning processes are the core processes for the changes of regional capabilities through the creation and exchange of tacit and codified the knowledge embedded in the organisations in a region/system (Lundvall, Johnson et al. 2002; Zollo and Winter 2002; Lundvall 2005). Therefore, regional capabilities accumulate and eventually influence the economic performance of firms and regions (von Tunzelmann 2009a).

Since the speed of changes in knowledge and capabilities in high tech is faster than in traditional sectors (i.e. agribusiness), global-local interactions, although useful to explain changes in capabilities in high tech sectors, are not completely suitable to explain the specificities of knowledge (tacit and codified) creation and exchange to fit the needs of the users (e.g. small dairy farmers and firms) in developing countries. One of the reasons is that specificities of the knowledge and technologies for agribusiness are closely related to local conditions, i.e. climate and natural endowments as well as numerous and complex interactions of actors and institutions because of the heterogeneity of the systems of production and disparities in the integration of value chains in regions. Therefore, there is a need to develop a different concept and an analytical framework, to understand how regional capabilities evolve overcoming the disparities of the actors and their technologies.

Lastly, a seven-function approach provides a framework for observing interactions in a systemic and systematic way for identifying and analysing specific capabilities. This framework helps to compare the dynamics of changes in regional capabilities (micro-meso level) focusing on the collective activities, processes and mechanisms (in other words, interactions) that actors in a region/system carry out collectively to create and diffuse knowledge for economic growth. The relationships between intra and inter firms and organisations capabilities are considered in terms of functions, which are ways of analysing the effectiveness or ineffectiveness of the interactions between different actors (not only dairy farmers and firms, but also these actors with other agencies of government, suppliers of inputs for agriculture, milk and dairy productions, etc.) at the level of regions whether or not supporting or delaying economic growth. In addition, the identification of blocking mechanisms and constraints that may impede learning processes in systems or delay capabilities building is especially important for firms with heterogeneous production systems (e.g. dairy farmers). Then, the analytical framework allows the assessment of regional capabilities in a particular sector and can be used to improve sector-specific policy making for future economic sustainability of dairy regions.

In order to understand whether regional capabilities have been created and accumulated in dairy regions of the MDS, and if they can support the sustainability of these dairy regions, the concept of *sector-specific regional capabilities* identifies and analyses capabilities that are found at a micro[142] level (i.e. dairy farmers and firms) and meso level (i.e. dairy regional development), which were created and accumulated in the modernisation processes of dairy regions (del Valle Rivera 2000) based on incremental innovation processes. These processes of innovation, as might be expected, differ across regions in terms of actors, technologies, systems of production, institutional sets-up, the boundaries of the processes, and the organisation of innovation processes within Mexican dairy regions. In order to identify these variations, this research develops an analytical framework [143] to operationalise the concept of sector-specific regional capabilities.

This research attempts to fill the gaps in the literature of evolutionary economics (i.e. firm, organisation and strategy and regional innovation systems) to identify regional capabilities in agribusiness, which has not been done before. These capabilities differ from manufacturing systems because they are related to geographic locations, technological progress and paths, and the socio-economic features of actors and institutions in the regions. This research attempts a) to explain the evolutionary process of capabilities building, i.e. the integration of the micro and meso levels on how traditional routines are replaced and/or changed as proposed by von Tunzelmann (2009a); b) to understand specific actors' interactions and their institutions, from the bottom-up, aiming to understand learning processes affected by top-down policies

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[142] The micro level evidence is based on previous research that sampled dairy farms and identified their changes in procedures and routines due to the increasing incorporation of knowledge and technologies; and the evidence that came from descriptions of changes in specific processes provided by dairy farmers and firms.

[143] This refers to what Cooke (2004 p 6) defines as a specific methodological approach, i.e. analytical framework. Using this systemic approach, entities are constructs, although they might not represent the totality of the real phenomenon.

(Howells 1999; Cantwell and Iammarino 2003; Iammarino 2005); and c) to test a 'policy prescription tool', i.e. a seven-function approach to make a systemic and systematic comparison of regional capabilities improving policy making to support capabilities building for sustainable economic growth of regions.

The sector-specific regional capabilities concept expands the logic of evolution of dynamic capabilities in firms to more complex open systems, regions/industries (and possibly countries). It places a central focus on changes in the capabilities of firms in regions that are the result of their interactions with other organisations (i.e. collective activities/processes/mechanisms), most of which imply learning processes and happen mainly at the local/regional level. However, some local-global interactions also happen because actors bring knowledge from multiple sources including outsiders (e.g. international suppliers and partners).

The sector-specific regional capabilities highlight individuals' interactions within and between firms and other organisations that lead to collective learning mechanisms (i.e. organisational and institutional learning). The resulting learning process influences changes in the micro processes that coevolve within organisations (intra organisational routines) and among them (inter organisational routines). Accumulation of the changes in these micro processes eventually contributes to more integrated capabilities within firms, the micro level, and at the region/system meso level. In addition, accumulation of change will reflect the growing number of firms, which change their practices in ways that are influenced by their regional and national institutions. These changes in regional capabilities eventually modify and possibly improve systems/regions' performance. In order to make a systemic and systematic analysis of the changes in capabilities, a seven-function approach provides a way of grouping or clustering capabilities, which contributes to patterns of functionality of the systems/regions for capabilities building and policy making.

This thesis argues that the foundation of the sector-specific regional capabilities concept is a system learning approach, which explains the coevolution of the micro processes within dairy farms and firms, intra organisational (which are embedded in the organisation of work) and technological routines (which are embedded in technological components) that coevolve in a more or less coordinated way to improve milk, dairy production and dairy regional development (e.g. herd management capabilities, new dairy product capabilities, research capabilities, etc.) because they are broader assemblages of complementarity routines.[144] Regional organisations, top-down policies and institutions influence these changes in the micro level of dairy farms and firms in regions.

The main theoretical bases involved in the development of the concept and analytical framework are summarised as follows.

Table 4.1 Theoretical bases and main elements that build up the concept of sector-specific regional capabilities and its analytical framework

Levels of observations	Theoretical bases	Main elements
Micro level	Dynamic capabilities	Changes of resources within firms and organisations due to coevolution of organisational routines (Nelson and Winter 1982; Penrose 1995; Teece, Pisano et al. 1997; Dosi, Nelson et al. 2000; Eisenhardt and Martin 2000; Zollo and Winter 2002)
Micro-meso levels	Collective organisational and institutional learning processes for capabilities building	Intra and inter organisations learning processes (Zollo and Winter 1999; Zollo, Reuer et al. 2002; Zollo and Winter 2002; Winter 2003; Zollo and Singh 2004) Institutional learning and user-producer interactions (Lundvall 1988; Lundvall 1992; Lundvall, Johnson et al. 2002)
	Regional capabilities	Regional capabilities for starting, regenerating and renewing regions by changing routines (Cooke 2005; von Tunzelmann 2009a)
	Regional system of innovation, RIS	Incremental innovations explained by bottom-up and top-down approaches (Howells 1999; Cantwell and Iammarino 2003; Iammarino 2005) Interactions and tacit knowledge as bases to explain learning processes and changes in routines and capabilities (Maskell and Malmberg 1999; Gertler 2001; Gertler 2003; Asheim and Coenen 2005; Asheim and Gertler 2005; Asheim and Coenen 2006)
	Sectoral systems of innovation, SIS	Sector specificities of knowledge and technologies and their sources and mechanisms for appropriation and accumulation involving learning to explain regional disparities (Carlsson and Jacobson 1997; Malerba 2002; Malerba 2004; Malerba 2005)
Micro-meso levels towards policy development	Function-based approach	Systemic and systematic observation of actors' interactions that contributed to capabilities and functions in systems to improve policy making (Cooke and Memedovic 2003; Bergek, Jacobsson et al. 2005; Cooke and Memedovic 2006; Jacobsson and Bergek 2006; Bergek, Jacobsson et al. 2008) Functionality and dysfunctionality of regional systems focus on the effectiveness and ineffectiveness of actors' interactions to improve systems performance (Carlsson, Jacobsson et al. 2002; Niosi 2002); and alignment and coordination of actors' interactions for capabilities evolution (von Tunzelmann 2004; von Tunzelmann 2009a)

Source: Author's elaboration.

[144]This is in line with the proposition of Levinthal (2000, p 364-368), regarding firms in complex systems.

Sector-specific regional capabilities are defined as the capacities of a region to change the micro processes of firms and organisations (coevolution of intra and inter technological and organisational routines) and their institutions to improve the production and commercialisation of competitive goods and services through interactive learning processes carried out by individuals within firms and organisations and among individuals from firms and other regional actors (e.g. research institutes, universities, technology transfer agents, suppliers of goods and services and government agencies). These interactive learning processes can also lead to changes in the capabilities of regional actors other than firms. Thus, sector-specific regional capabilities have the potential to affect the sustainability of economic growth of a specific sector in a region.

The central claim of this research is that *sector-specific regional capabilities* are the result of multiple and complex interactions, some of which imply learning processes which change heterogeneous types of knowledge (e.g. explicit, implicit, tacit and codified, etc.), among individuals within firms or any other organisations (or actors) (intra organisation capabilities), and among individuals from different firms and/or organisations (or actors) (inter organisation capabilities) in a specific location affected by a socio-economic institutional set-up. Therefore, they are a result of the extent of appropriation and accumulation of changes in the routinised processes. This concept emphasises that the coevolution of capabilities are intended processes, which require purposive learning, allocated resources and time to change.

In Table 4.2, we propose two main groups of ‘stylised’ capabilities included in the concept of sector-specific regional capabilities, which will guide the identification and analysis of capabilities in the regions. They are intra firms and/or organisations (or actors) capabilities (micro level), which comprise technological and organisational (managerial) capabilities (regarding specific knowledge content), and inter firms and/or organisations (or actors) capabilities.

Table 4.2 Sector-specific regional capabilities

Knowledge content	Intra firm or intra organisations (actors) capabilities (more generally intra organisational capabilities)	Inter firm or inter organisations (actors) capabilities (more generally inter organisational capabilities)
Technological	Technological capabilities for R&D, production, manufacturing, etc.	STI research capabilities, production capabilities, IPR capabilities, technology transfer capabilities, competitive marketing capabilities, entrepreneurial capabilities, policy making capabilities, mobilising economic resources capabilities, capabilities for normalisation and standardisation of industries, alliance-making capabilities, etc.
Organisational (managerial)	Strategic management capabilities such as communicating vision, setting new goals, motivating people, managing risk, project management capabilities, operations capabilities, etc.	

Source: Author's elaboration.

It is important to note that whereas dynamic capabilities are properties (or emergent properties) of firms/organisations/actors, regional capabilities are properties (or emergent properties) of the system/region and not just an aggregation of the (dynamic) capabilities of the firms and organisations in a region because they evolve and become a firm/region.

In this research, we reflect on changes in the patterns, repetitive, or recurring ways of individuals within firms to do something (procedures or organisational routines) (following Cohen, Burkhart et al. 1996), which the clusters or assemblages of these routines and procedures constitute the capabilities of firms/organisations in a specific time frame. Organisational routines, or operational routines, evolve over time into improved or new capabilities because individuals and organisations find gaps between what would be desirable and the actual performance (following Iansiti and Clark 1994). Thus, a group of individuals' collective participation within firms and organisations in systems/regions might change their organisational routines into new improved ones (following Feldman 2000) leading to improved or/new capabilities.

It is important to note that these processes are not linear, nor mechanical. They may be very disordered because of the individuals involved in the changes, who might resist change for various reasons such as a lack of knowledge and understanding, cultural issues, or lack of ability to interpret uncertainty of the outcomes. Therefore, stages of learning and negotiation among individuals take place, which may imply delays.

For this research, o*rganisational routines* are the micro processes or building blocks of capabilities. Individuals carry them out without much reflection because they have proved to be effective under specific conditions. In other words, they embed tacit and codified knowledge and specific objects and artefacts. They change over time through the reflection of individuals doing the procedures or routines, by the introduction of new methods of doing things, by challenges done by other individuals and by changes in management styles if environmental conditions change (e.g. recruiting new managers, skilled and specialised labour facing changes in the business environment) and become improved and/or new *organisational capabilities or managerial capabilities* specific for a firm or organisation (e.g. TQM, ISO 1900, JIT, etc.). If the individuals or groups of individuals in a firm introduce new knowledge, technologies and artefacts, specific to the production processes or products, they may also have to change their technical or technological routines or procedures, which coevolve towards improved and/or new *technological capabilities*.

Intra firm or intra organisations (or actors' capabilities) evolve through organisational learning processes, for which management function in a firm or an organisation organises and coordinates the changes in organisational routines among individuals and departments. Thus, improved and/or new sets of capabilities are expected to achieve better results than the previous sets of organisational routines on which they are founded. This is achieved when individuals carrying out changes in former routines no longer negotiate them.[145]

The evolution of routines and capabilities is affected by the institutions prevailing in the firm or organisation, but also may be affected by policies and institutions prevailing in the system/region where the firms or organisations are located. The changes of routines into improved and new capabilities could also be influenced by other individuals from other firms and organisations (e.g. government organisations, research institutes, suppliers of technologies or inputs, organisations for development, universities and non-profit organisations).

[145] This might imply reducing transaction costs within firms as proposed by Jacobides and Winter (2005).

From inter firms or inter organisations or inter actors' interactions, we infer improved and/or new *inter firms or inter organisations or inter actors capabilities*, when these interactions involve collective learning processes (organisational and institutional learning) within the system/regions. Their evolution is promoted by the alignment of multiple actors and/or coordinated and/or directed by one firm, organisation or actor (i.e. centralised) or various firms, organisations or actors (i.e. decentralised), which might have the power and resources to do so. The institutional set-up in the prevailing governance [146] of a system influences them and they themselves influence the institutional set-up and possibly the policies. They may have a higher order of capabilities than the intra organisational capabilities because they might involve changes and alignments in the routines, technologies, artefacts and capabilities of multiple actors with different types of specific and complementary knowledge and skills. They generate outcomes, which the participants are not individually capable of achieving. Therefore, the coevolution of intra and inter organisation capabilities provides a way of understanding the integration of the micro-meso levels of regional capabilities.

As discussed in subsection 3.4.3, in practice, technological and organisational (managerial) capabilities are intertwined, co-evolving and difficult to distinguish. However, an effort to distinguish them in this research helps to disentangle the complexity of the actors' interactions and the design of future policy making as this research proposes to improve regional policies in order to improve firms' capabilities. For instance, if what is needed is to improve technological capabilities, technical training programmes for individual users/firms or organisations in specific techniques and technologies should be included in the policies[147]. However, if reorganisation of supply chains, alliances among firms in a sector or regions are required, with development of new knowledge on searching for partners, and the development of managerial skills such as negotiation and project management capabilities should be included in policies as much as other training to improve policy making capabilities to affect the entire system/region. This might imply the development of a new vision and

[146] Governance refers to consistent management, cohesive policies, processes and decision-making processes for a given area of responsibility. In this case, we refer to the setting in motion of learning processes in a system/region.
[147] This is consistent with von Tunzelmann (2009a) who argues that it is important to search for the sources of knowledge (i.e. laboratories).

aim to align the purpose of different actors through policies as well as negotiation and coordination of training and learning processes to implement policies, which eventually might imply changing institutions or creating new ones.

Regional capabilities development might also use generic technologies and artefacts such as information technologies to help firms and organisations organise and standardise their procedures and routines and eventually support their capabilities (Pablo, Reay et al. 2007) .[148]

In the operationalisation of a concept to compare systematically the capabilities of regions, because there is no consensus about which functions/processes/activities should be included in such an analysis (Bergek, Jacobsson et al. 2005; Edquist 2005), this research uses the seven functions proposed by Jacobsson and Bergek (2006),[149] which have been used successfully in developing contexts to identify and to analyse the formation of capabilities (e.g., engineering, design and research capabilities) in the early phase of the evolution of the Korean machinery industry, the Brazilian aerospace and steel industries and the Chilean salmon farming.

This research made further interpretations of the indicators related to the seven functions (see Table 4.9) provided by Bergek, Jacobsson et al. (2005) (Table 3.3). These interpretations guide the search to identify main interactions that might have contributed to capabilities evolution in regions. By using this approach, it is possible to understand the regional capabilities accumulation (incremental innovation) due to the degree of alignment and coherence of processes and mechanisms that change them and/or improve something in the system/region, which contributes to one or some of the seven functions. Therefore, they may contribute to the good performance of the system, and the system might have a functional pattern (Jacobsson and Bergek 2006; Hekkert, Suurs et al. 2007). On the other hand, when there is lack of coordination, misalignment and/or

[148] Pablo, Reay et al. (2007) provide a well-documented case of the identification and analysis of capabilities evolution in the public sector, which provides evidence on how some organisations in the Calgary Health Region responded to the need for continual performance improvements despite reduced financial resources.

[149] This thesis does not discuss further the limitations of a function-based approach because this is beyond its scope, as it was explained in section 3.5.

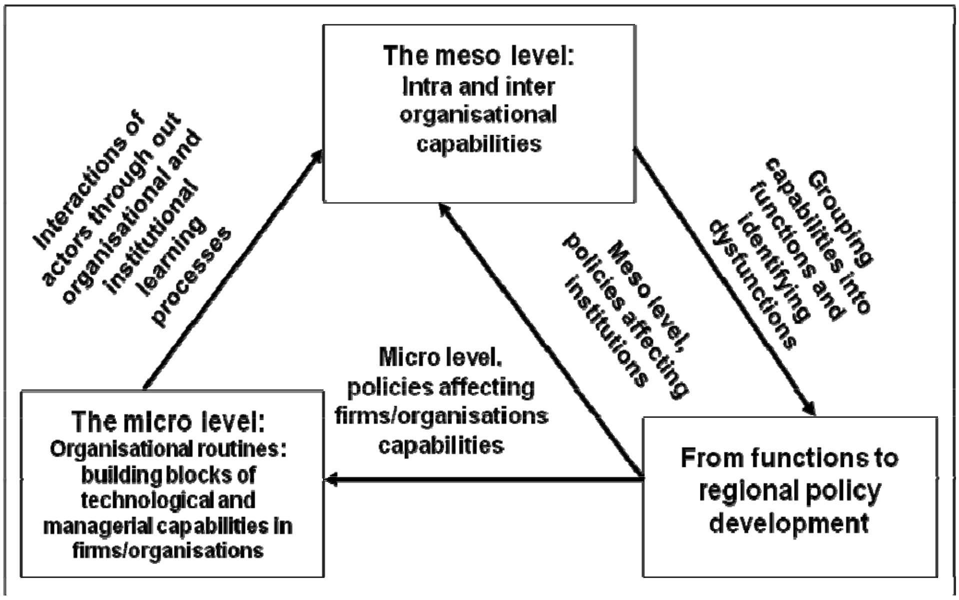
incoherence in actors' interactions to change some routines and parts of the systems, the system/region might have a dysfunctional pattern for capabilities building.

This research maps out systematically inter organisation interactions, qualify them and identifies the blocking mechanisms and constraints of the system/region. In this ways, it is possible to identify aggregated capabilities and 'what is (or not) achieved' in a specific innovation system in terms of the seven key processes/functions and dysfunctions chosen for closer examination in the regions.

Figure 4.1 depicts an analytical framework that operationalises the concept of sector-specific regional capabilities, which addresses areas of observation of the actors' interactions and their analysis:

1) the micro level: the identification of changes of specific routines and procedures of the technological components of firms (dairy farms and firms) (see criteria set up in Tables 4.7 and 4.8) that were affected by other firms/organisations and led changes in technological and organisational or managerial capabilities. This will be done by identifying collective activities/processes/mechanisms (or interactions) using the seven functions framework (see Table 4.9) among these actors that might have set in motion some learning mechanisms (internal and external to firms and organisations), i.e. organisational and institutional learning processes,
2) the meso level: the identification of inter organisational capabilities in regions will be done by grouping and/or clustering intra organisational capabilities and analysing the actors participating in these changes. In this way, we also identify the inter organisational capabilities that contributed to specific functions and identify missed or underdeveloped capabilities, which made the system/region less functional or dysfunctional. The main assumption here is that functions are grounded or founded in intra and inter organisational capabilities, or at least the *changes* in functions are grounded in *capabilities building processes*, which support the growth of firms/organisations and regions. Therefore, capabilities facilitate (or are helpful in) and are necessary conditions for the well-functioning of a system; and

3) from functions to regional policies: the analysis of the functional/dysfunctional patterns of system/regions for building and accumulating regional capabilities will be done by qualifying these regional capabilities (i.e. basic, operational and strategic, see subsection 4.4.3). The analysis of the regional capabilities qualifications will be the bases for developing regional policies recommendations. Regional policies will focus on improving actors' interactions on two levels a) to support capabilities of firms/organisations, and b) to change institutions at the level of the region/system to support capabilities' evolution.



Source: Author's elaboration.

Figure 4.1 Analytical framework for sector-specific regional capabilities

This is an effort at sense making or 'appreciative theory'[150] (Santangelo 2003) given the absence of standardised methods in the literature (Nelson and Winter 1982).

4.2.1 A staged approach of the development of capabilities in systems

This subsection hypothesises on the continuous process of how capabilities evolve in systems.

Traditionally, the number of new products, processes, services and their ability to expand and/or create new markets are indicators of firms' development. To make these

[150] Appreciative theory provides the basis for formal theory. It is concerned with what the analyst thinks is going on. Therefore, it is usually expressed in terms of storytelling (Santangelo 2003).

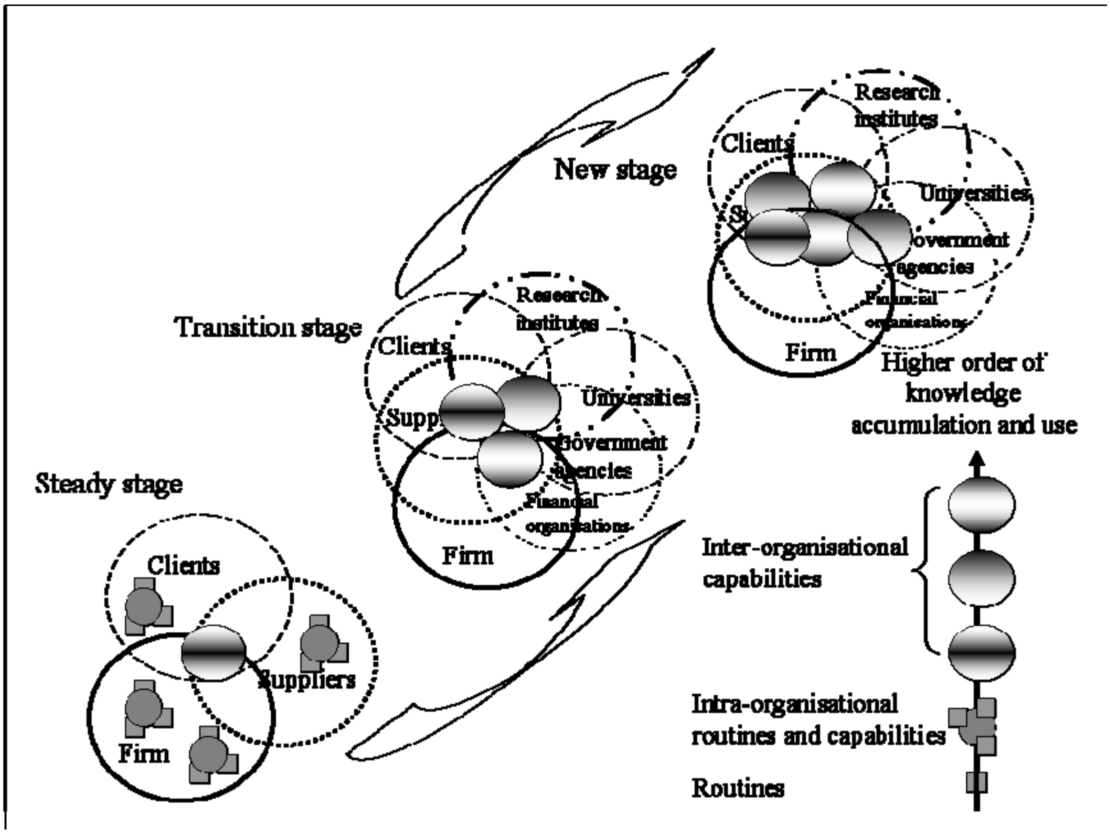
changes, firms must be able to articulate and reconfigure the knowledge and skills of individuals in firms with knowledge and skills from external organisations, to develop capabilities. In this articulation, the division of labour is important because it shapes capabilities building. As management works in firms (Jacobides, Knudsen et al. 2006), so institutions (Nelson and Nelson 2002; Nelson 2005; Nelson 2008) and powerful actors do in innovation systems. Management in an organisation can dictate a concerted approach in all divisions by reframing, integrating, coordinating and controlling organisational routines that create more appropriate cognitive structures to affect the organisation's capabilities to adapt and respond (Jacobides 2007, p 470). Such an organised approach or coordination is almost impossible in a set of interdependent firms and other organisations in a system/region. However, vertical integration of firms and suppliers and the linkages of firms with other organisations leads to different patterns of evolution of industries (Jacobides and Winter 2005)[151], in which the actors governing the industry in a specific region might impose standards of production, quality of products and other rules that affect the organisational routines and capabilities of the ones integrated.

Systems evolve capabilities similar to the way that firms do because of the division of labour of the actors in a system. Firms and organisations can be seen as 'closed' systems because their functions and boundaries are 'better' defined than in a system/region, which is why the study of capabilities in firms, i.e. dynamic capabilities is better understood. Nevertheless, the collaborative activities, processes, mechanisms of organisation and coordination functions are not easy to distinguish and overlap in both systems can be found. Therefore, explaining collective activities, processes and mechanisms that firms and other organisations carry out is one way to provide evidence for capabilities development in firms (Helfat, Finkelstein et al. 2007) and eventually in systems/regions, as this thesis argues, when multiple actors participated (i.e. networks for learning) in specific functions (see Table 4.9). [152] However, the structure of the actors, their political and economic forces and institutions (i.e. tensions) coordinate, organise and hold in place interactions among themselves in systems (Nelson 2008, p 8).

[151] The dynamics of capability and transaction cost coevolution are illustrated in two contrasting examples: the mortgage banking industry in the US, which shows a shift from integrated to disintegrated production; and the Swiss watch-manufacturing industry, which went from disintegration to integration (Jacobides and Winter 2005).
[152] The specific examples of participants in the collective activities/processes/mechanisms in each of the cases are shown in Tables 5.8, 5.19 and 5.27.

They create the institutional set-ups and governance that stimulate or block the institutional learning among the actors to coevolve their intra and inter organisational capabilities.

The stylised stages in the changes of capabilities in systems/regions to be explained in this research are depicted as follow:[153]



Source: Author's conceptualisation.

Figure 4.2 Evolution of capabilities in systems

a) The steady stage is characterised by firms and underlying support organisations with low incentives to change (e.g. a protected market). It might also be that firms find themselves in a market where profitability is low (i.e. mature sectors) and they are focused on staying in the business because there are no new business opportunities to pursue. Firms also might be in a 'comfort zone' where exit costs could be higher than the costs of keeping the business running. The length of this stage is important. If the firms and underlying actors' supporting systems have been in very steady markets for a long time, they might find difficulty in facing changes in the environment, which is not

[153] Based on Baden-Fuller and Stopford (1992) and Porter (1990).

the case for more dynamic markets and sectors (e.g. ICT systems, biotechnology, etc.) where the actors react and adapt to change quickly. This stage is characterised by firms/organisations with clusters of organisational routines and capabilities, which have proved so far to be efficient in such an environment.

b) The transition stage is triggered by several factors and forces such as i) increasing competition by opening markets, ii) speeding up of technological change, iii) interactions of other actors (e.g. suppliers, consultants and government organisations) pushing and influencing firms to change, either improving their processes [154] and technologies or acquiring new technologies and artefacts, and iv) firms recruit new personnel including changes in firm management. These factors and forces provoke individuals and groups of individuals inside the firms to identify gaps in their production systems and respond in several ways. They might update their knowledge and change their organisational routines into improved and/or new intra organisational capabilities to adapt to the new conditions. Furthermore, these interactions of firms with other organisations also provoke changes in the capabilities of the whole system (i.e. inter organisational capabilities).

This stage implies firms might develop the following strategies: 1) to acquire a completely new set of routines, technologies and capabilities to change the entire business core, 2) to improve the firms' current routines and therefore their capabilities to stay in business without losing money or to improve them and expand their products and markets to outdo competitors; and 3) to close down and lose the accumulated capabilities.

As explained before the processes are not linear, nor mechanical. The length of this transition stage depends on how fast individuals or groups of individuals (i.e. agency of individuals) within firms develop and acquire the necessary resources, knowledge and technologies to change their routines and eventually their capabilities. It also depends on how well the organisations with which firms interact are able to supply the resources, knowledge and technologies (i.e. products and services) that firms need to pursue their

[154] For example, implementation of ISO 9000 might promote an array of changes in organisational routines in order to comply. This might favour a learning process involving different mechanisms (e.g. experience accumulation, knowledge articulation and codification) in a conscious or unconscious way (i.e. routinisation of new activities).

new aims; in other words, how well those organisations fit the needs of firms to support their capabilities building processes.

This stage is characterised by organisational and institutional learning processes and negotiation carried out by firms and other organisations, which are affected by their institutional set-ups. Then, intra and inter organisational capabilities coevolve, which might also in turn change the capabilities of the system to face the business environment.

c) A new stage implies some rearrangements in the structure of the industry, actors, networks and institutions. Successful firms have been through learning processes, overcome negotiations among individuals or groups of individuals and settled into new patterns of routines and capabilities (higher levels of routines and/or new combinations and assemblages). They managed to update their structures and technologies to meet business challenges, develop new products and so on. This stage might involve a restructuring of the entire system (e.g. entry of new firms and exiting of incumbents). This stage also involved that actors in the system might have increasingly aligned their purposes and aims in order to integrate better their value chains and to advance the industry.

When firms and other support organisations have developed capabilities,[155] but the conditions and prerequisites in the environment are not present (e.g. rigid institutions, lack of economic resources, etc.), the system (i.e. dysfunctional, incoherent and/or misaligned) will lag behind. However, in the event of a system with a dysfunctional pattern (i.e. incoherence and/or misalignment of actors' processes) or with a system failure, firms might switch to other economic activities or form different production clusters (e.g., new associations of producers, mergers and acquisitions, etc.).

The changes in capabilities of other organisations different from firms also depend on the stage of their capabilities in the steady stage. It could be that the capabilities of those organisations do not fit and/or coevolve their products and services as fast as the firms need, and therefore, they might contribute to the failure of the system.

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[155] Here we understand the propensity to react (Dougherty, Barnard et al. 2004).

Once the new stage is reached and a new set of routines and capabilities are set up, a new steady stage is achieved because there is no more negotiation among the individuals carrying out the routines about the use of technologies and the organisation of work. It might be possible that new changes in the environment affect the system and/or individuals in the firms and organisations are aware of new forms of work and/or technologies, so the changes start again, which might result again in changes of the system's capabilities. However, these stages can be seen as coevolutionary and path dependent.

In brief, this section identifies gaps in the literature and builds up the concept of sector-specific regional capabilities and an analytical framework to explain changes in regional capabilities integrating the micro-meso levels and proposes a staged approach of capabilities development in systems.

The following section undertakes the operationalisation of the concept using the analytical framework for this research.

4.3 Multiple-case studies, the research method and its strategy

This research identifies how dairy firms' and milk suppliers' capabilities changed through their interactions[156] (i.e. institutions and networks) with other actors in the MDS based on evidence from the La Laguna, Los Altos and Tabasco dairy regions, located in different climates, which affect their milk production systems. This analysis might allow some generalisation to be extended to other dairy regions (see Table 4.3).

[156] We argue that these interactions are the embedded units of analysis in these three regions following Yin (2003b), p 12.

Table 4.3 Selected dairy regions and their climate regions

Selected dairy regions	Dominant milk production system	Other states with similar climate regions
La Laguna region, in Coahuila and Durango states	Specialised systems, intensive systems or Holstein systems	Arid and semi-arid regions: Chihuahua, Baja California Norte, Baja California Sur, Nuevo León, Tamaulipas, Sonora, San Luis Potosí and Zacatecas
Los Altos, in Jalisco state	Semi-specialised, semi-intensive and familial systems	Temperate regions: Guanajuato, Estado de México, Hidalgo, Aguascalientes, Puebla, Michoacán, Queretaro, Tlaxcala, Morelos and Distrito Federal
Tabasco state	Non specialised, extensive or dual-purpose systems	Tropical regions: Veracruz, Guerrero, Chiapas, Oaxaca, Campeche, Yucatán, Quintana Roo, Sinaloa, Colima and Nayarit

Source: Author's elaboration of data from SAGARPA (2000).

In these three dairy regions, this research identifies systems' actors involved in complex interactions (i.e. purposive activities/processes/mechanisms), formal and informal (i.e. routinised and non-routinised processes), which provide evidence for the proposed appreciative capabilities building theory (a system learning approach) (section 4.2) to identify and analyse the intra and inter organisational capabilities of firms (i.e. dairy firms and dairy processors) that changed in the regions. From these identifications we carry out a cross-case analysis to understand their implications in the changes of regional capabilities, which contributed to specific functions and dysfunctions in dairy regions and from this analysis, this research elaborates specific regional policies aimed at sustaining economic growth of the dairy regions.

From a research point of view, a multiple-case studies method has been found to be an appropriate method for theory building[157] (Eisenhardt 1989; Yin 2003a; Yin 2003b). This thesis argues that capabilities are central processes in innovation systems, based on the analysis and comparison of three regional dairy systems. The centrality of the concept of sector-specific regional capabilities and the analytical framework applied here is, nonetheless, provisional. Further research may provide a basis for a revision of the theory and pursuit of new types of evidence (Eisenhardt 1989).

The multiple-case studies method relies on several sources of information to create the evidence through a process of triangulation because the method is iterative and tightly linked to the available data (Eisenhardt 1989; Yin 2003a). Thus, the comparison of

[157] Theory building involves measuring constructs and verifying relationships, which is a similar process to traditional hypothesis-testing research. However, these theory-building processes are more judgmental than those in traditional hypothesis-testing research because statistical tests cannot be applied. Therefore, researchers look for strength and consistency within and across the cases and demonstrate evidence and procedures for their findings (Eisenhardt 1989).

regions has to cope with technically distinctive situations in which there are more variables of interest than specific indicators, which might represent some parts of the economic performance and outcome of the development of capabilities in regions (e.g. milk production, new dairy products, milk production capacity, etc.).

The logic underlying the use of a multiple-case studies method is that it either predicts similar results (a literal replication) or contrasting results, but for predictable reasons (a theoretical replication) as expected in experimental science.[158] However, one important feature of all replication procedures is the support of a theoretical framework. In this case, an analytical framework (see Figure 4.1) provides a platform on which the particular phenomenon (i.e. the development of capabilities) is likely to be found (literal replication) as well as the conditions in which it is likely to be found (theoretical replication). If the empirical cases do not work as expected, modifications will need to be made to the concept and its analytical framework[159] (Eisenhardt 1989; Yin 2003a).
Another advantage of the multiple-case studies method is that it reduces the vulnerability inherent in a single case approach and improves the robustness of the findings for different regional contexts, i.e. 'generalisability' of conclusions to other regions and possible other agribusinesses.

In summary, the analytical implications of this research method are: a) it is a multilevel approach (micro-meso) to capabilities development within each region; and b) it uses a systematic comparison of the regions based on the changes carried out by dairy farmers and firms and their systems in the same economic contexts (i.e. Mexican dairy regions after NAFTA).

4.3.1 Why three regions

Mexico has approximately twenty milk basins or dairy regions (Alvarez Macías and Montaño Becerril 1997; Peralta Arías and Lastra Marín 1999), which include great heterogeneity in milk production systems and value chains' integration. However, as a Federal republic, Mexican regions are governed by the nation state and by meso-level

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[158] This is the logic followed by scientists carrying out multiple experiments, i.e. to follow replication logic (Yin 2003a, p 47).
[159] Yin (2003a, p 48) asserts that theories must be practical, not just academic. Therefore, the analytical framework could be modified for different purposes.

political units or state governments. These regions are relatively 'culturally homogeneous' (compared say with China or Europe).

In the preliminary data collection and in-depth interviews carried out in February and March 2004 in Mexico, Mexican researchers argued that in order to understand the capabilities development in dairy regions, the study of at least three contrasting regions is necessary to identify the diversity of capabilities building processes (Cervantes Escoto 2004; del Valle Rivera 2004).

Choosing regions with major differences (e.g. milk systems of production, climatic conditions including availability of water,[160] historical paths, structure of production, number of farmers and dairy processors and institutional arrangements) and similarities (i.e. reasonable homogeneity in the use of the technologies and similar farmer support organisations) following Yin (2000a; 2000b) and Eisenhardt (1989), we might be able to generalise to other dairy regions.[161] Each region, however, constitutes a unit of analysis. The specific features of the chosen regions are listed below.

1. La Laguna region located in the northern central part of Mexico. It occupies an estimated 47,887 square kilometres and comprises 15 municipalities, 10 in Durango state and 5 in Coahuila state.[162] Its climate is harsh for raising cattle, being arid and semi-arid desert. Summers are very hot and dry, with little rainfall throughout the year and average temperatures of 35-37°C from May to August; and winter temperatures from 2-15°C but which can go below 0°C during winter. La Laguna changed from cotton growing to milk production in the early 1950s.

La Laguna dairy region is the largest and most successful in the country, with milk production highly concentrated in large dairy producers with specialised systems. It has become the benchmark for other regions with similar climate conditions in the states of

[160] Average annual rainfall for the regions is 50 mm for La Laguna, 150 mm for Jalisco and 250 mm for Tabasco.
[161] Clearly international comparison within specific areas of dairy technology could shed light upon the creation, evolution and/or decline of the system (Carlsson 2002), but this is outside the scope of the thesis.
[162] The municipalities in Durango are Mapimí, Tlahualillo de Zaragoza, Gómez Palacio, Lerdo, San Luis del Cordero, San Pedro del Gallo, Rodeo, Nazas, Simón Bolivar and San Juan de Guadalupe; and those in Coahuila are Torreón, San Pedro, Matamoros, Francisco I. Madero and Viesca.

Chihuahua and Querétaro. The transformation of La Laguna was accompanied by important economic, technological, and social changes (del Valle Rivera 2000; García Hernández, Martínez Borrego et al. 2000; Martínez Borrego and Salas Quintanal 2002; Salas Quintanal 2002).

2. Los Altos located in the northeast part of Jalisco, includes 19 municipalities.[163] Jalisco has been producing milk since colonial times and has one of the most traditional milk production systems, the family farm, and uses various technologies. It is a region in transition following La Laguna's milk production model and is the benchmark for Michoacán and Guanajuato milk producers (Rodríguez Gómez 1998a; Rodríguez Gómez 1998b; Chombo Morales 1999; Cervantes Escoto, Santoyo Cortés et al. 2001; Cervantes Escoto 2003).

3. Tabasco (a one-state region) located in the heart of the tropical region, is an important production area for agriculture and livestock and comprises 17 municipalities.[164] Its climate (average temperature of 26°C, but reaching 45°C during summer with relative humidity of 70-85%) is extremely harsh for dairy cattle (del Valle Rivera 2000). Small family farmers across the state use dual-purpose milk production systems which results in great heterogeneity in terms of farm sizes, technological development, and productivity and quality of milk (Muñoz Rodríguez, García Muñiz et al. 2003) compared with the other two regions, and makes integration of the value chain difficult.

The Mexican government and other development organisations have argued that tropical regions have a high potential for milk production[165] because of their ample water supplies and grasslands. These features provide a 'natural' comparative advantage for agriculture and cattle compared to the arid and semi-arid regions in the northern and

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[163] The municipalities are Acatic, Arandas, Encarnación de Díaz, Jalostotitlán, Jesús María, Lagos de Moreno, Mexticacan, Ojuelos, San Diego de Alejandría, San Juán de los Lagos, San Julián, San Miguel el Alto, Teocaltiche, Tepatitlán, Unión de San Antonio, Valle de Guadalupe, Villa Hidalgo, Villa Obregón and Yahuilica.

[164] The municipalities are Balancán, Cárdenas, Centla, Centro, Comalcalco, Cunduacán, Emiliano Zapata, Jalapa, Jalpa de Méndez, Jonuta, Huimanguillo, Macuspana, Nacajuca, Paraíso, Tacotalpa, Teapa and Tenosique.

[165] Federal programmes have been launched to support the development of milk production in the region, e.g. the Chontalpa plan launched in the 1970s and the Tabasco 2000 project launched in 2000, which includes the development of a dairy cluster in Tabasco.

western parts of the country, which require intensive use of technology and water. However, there is no clear evidence of the comparative advantage for milk production, for which government initiatives need further research (Alvarez Macías and Montaño Becerril 1997; Dávalo Flores 1997; Hernández Laos and del Valle Rivera 2000).

The criteria used to select the regions for the cross-cases comparison were as follows:

a) economic dynamism of the regions demonstrating exemplary outcomes (Carlsson, Jacobsson et al. 2002) and contrasting outcomes (the case of Tabasco). It does not measure individual performance of the actors in the system; instead, it addresses economic performance in the different dairy regions to eliminate the sources of heterogeneity in the regional systems (Cooke 2004; Heidenreich 2004; Cooke 2004a). Regional economic performance was assessed for purposes of case selection in this research by the growth rate of regional milk production, and the development of new products, markets and the positioning of regional dairy firms in the national dairy market in the period from 1994 to 2004. Other conventional measures could have been used, e.g. patents, numbers of engineers and scientists, etc., to proxy for capabilities accumulations and eventually to functions. However, most of these indicators are not available because of the nature of the technologies used in the sector, e.g. patents are not suitable (Carlsson, Jacobsson et al. 2002). La Laguna has increased its participation in milk production, and it has also grown faster than the other two regions; Jalisco's participation has remained almost the same and Tabasco seems to be decreasing (see Chapters 5 and 6). The control variables are the growth rates of milk production and the size of the herd and changes in the share of milk production in the same period (see Table 6.1).
b) 'perceived' homogeneity of the technological milk production systems among the selected regions due to similar climatic and cultural features. This is the 'replicator' type criteria employed in case study research, where similarities in climate, and to some extent, culture suggest the results could be generalised to other state regions (see regions in Table 4.3) as suggested by Cervantes Escoto (2004) and del Valle Rivera (2004).
c) industrial structure of each regional system. Although different, each region has in common at least one large domestic dairy firm, which integrates a major share

of that region's dairy farmers (i.e. Lala in La Laguna region, Sigma Alimentos in Los Altos and Ultralácteos in Tabasco).

In identification and analysis of the regional capabilities we have to bear in mind different features of the sectors for the specific knowledge base, technologies, inputs and demand, which are related to their geographic location[166] as well as to the markets they serve (Malerba 2002; Malerba 2004). Therefore, different suppliers of knowledge and technologies will explain the regional differences in capabilities development and performance. The features of the sector are:

a) the unique nature of the milk production (*cf.* manufacturing systems), influenced by climate, agricultural infrastructure (e.g. irrigation and transportation), size of production units and production organisations, which require complementary support systems (e.g. government support for research and funding to create infrastructure);

b) the technological components and knowledge bases that are diverse and numerous combinations of each component and at different locations lead to different patterns of innovation (e.g. systems of milk production and product and market development) and capabilities development (see sections 2.3 and 2.4);

c) the appropriability of the knowledge, which is very idiosyncratic at a local level, especially in the primary sector, where the culture, social behaviour and absorptive capacities of farmers are key factors influencing knowledge transfer of users (Lundvall 1988) who determine the way that knowledge is accumulated, enhanced or distorted and shared;

d) the cumulativeness of knowledge is highly localised because it is related to how technologies are implemented in the regions (tacit knowledge and capabilities development). Therefore, the innovation process is further influenced by the individual aims of farmers, e.g. farmers choosing to specialise in beef or milk production in the case of the dual-purpose system;

[166] It is important to note the emphasis is on regional learning processes (Maskell 2001; Lundvall, Johnson et al. 2002). It does not imply that the sum of the regional dairy systems amounts to the socio-economic and technological behaviour of the national system (Sharif 2006). It attempts to provide a better insight into the regional dairy systems from the specificities of learning and capability accumulation in the regions and to define the needs for national coordination and rule setting (Lundvall, Johnson et al. 2002; Lundvall 2005) to improve regional policies for better performances in milk and dairy production.

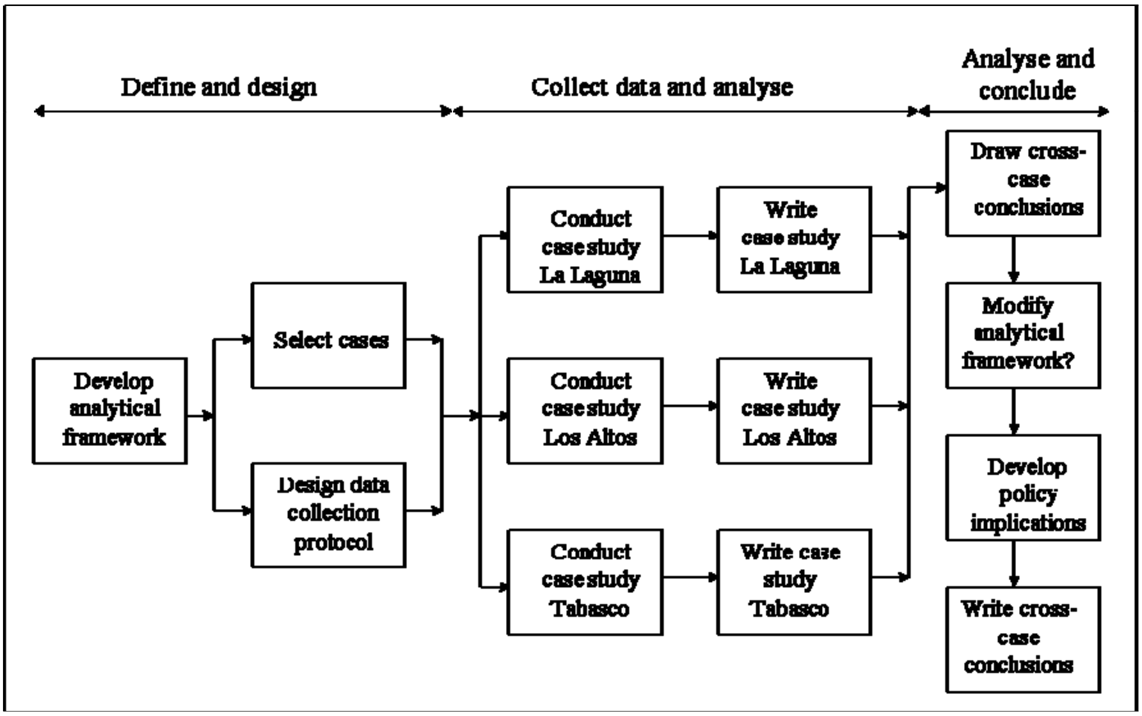
e) the dissimilarity of appropriability and cumulativeness knowledge across regions means the level and range of research in universities and research centres, the presence and effectiveness of science and industrial links, the vertical and horizontal integration among local firms, users and producers' interactions and the kind and level of firms' innovative efforts matter for the achievement of progress or failure to make progress in regions (Nelson 1993);

f) the dairy sector is supplier-dominated with some elements of scale-intensive sectors (Pavitt 1984). Therefore, the main technological changes might come also from external sources. Nevertheless, because knowledge and learning processes differ among regions, regional experience shapes the technologies and processes involved. It is likely that in the milk production systems, the levels of labour force literacy and skills, as well as the skills and technical competence of veterinarians and agriculture specialists, play a significant role. In dairy processing firms, performance depends on management efficiencies in R&D, production, marketing and financial activities according to established and understood models derived from MNC experience, local imitation and/or international best practice.

4.3.2 Analytical strategy

The research strategy includes an array of data collection and data analysis techniques (see Figure 4.3), which provide comprehensive answers to how capabilities are built in complex systems where actors' activities and processes are intertwined in their social and political contexts. This provides the basis for understanding functions in regional systems related to economic exemplary outcomes.[167]

[167] Exemplary outcome will reflect strong positive (or negative) examples of the development of capabilities in dairy systems (Yin 2003b, p 13).



Source: Modified from Yin 2003a, p 50.

Figure 4.3 Research multiple-case studies method

The analytical strategy focuses on observing how supporting organisations (e.g. research institutes, government organisations, suppliers of inputs for milk and dairy production, universities and other development organisations) interacted and influenced the collective activities/processes/mechanisms conducted by dairy farmers and dairy processors in the period 1994-2004. The interactions that created some ways of learning were identified and analysed because they provide the bases for understanding the evolution of intra and inter firm or organisations capabilities based on the analytical framework. To do so, a multiple data collection method was used:

a) a total of 120 in-depth semi-structured interviews with members or actors in the regional dairy systems (see Table 4.4). The interviews were designed to elicit information on observable changes in dairy farmers and firms (see interview guideline for firms' executives in Table S4.1) and supporting organisations (see interview guideline for supporting organisations' executives in Table S4.2), which shaped regional development of milk and dairy production. The identification of interviewees followed the snowballing. The interviews were carried out between May and September 2005;

b) multiple secondary sources, such as previous research on the MDS, Mexican and US government reports, firm and organisation reports, electronic sources, etc.

Table 4.4 Sample distribution of interviewees

Interviewees	%
Cattlemen association presidents, operatives and farmers	22
Private firm directors and operatives	24
Suppliers of inputs and services directors, operatives and specialists	16
Researchers from public organisation and universities	16
Government organisation directors and operatives	14
Financial organisation operatives	8
Total	100

The empirical data (a) were collected through a set of 64 semi-structured in-depth interviews from 14 site visits in the three dairy regions (see Table 4.5).

Table 4.5 Interviewed organisations in the regional dairy systems

Main organisations/regions	La Laguna region (Torreón and Matamoros in Coahuila state and Gómez Palacio, Nazas and Lerdo in Durango state)	Los Altos region (Acatic, Encarnación de Díaz, Valle de Guadalupe, Guadalajara, Tlaquepaque, and Lagos de Moreno)	Tabasco (Villahermosa, Cárdenas and Huimanguillo)
Milk and dairy processors, main firms	Lala	Lechera Guadalajara Alimentos La Concordia Nestlé Sigma Alimentos LDM LICONSA	Ultralácteos
Dairy farmers	Granja Ana Rancho Santa Bárbara	PROLEA	Rancho San José
Cattlemen association	UGR La Laguna	UGR Jalisco AGLLM AGLOj AGLUSA	UGR Tabasco
Suppliers of inputs for milk and dairy production	GEMEX Madero Equipos de Ordeño	Ordeñadoras de México	‘Ganaderos’ Semillas Papalotla
Research organisations	INIFAP Matamoros	INIFAP Jalisco CIATEJ CIESAS CIPEJ	INIFAP Cárdenas
Financial organisations	FIRA Torreón office	FIRA Lagos de Moreno office	FIRA Villahermosa office
Universities	ITESM, Campus La Laguna UAAAN		COLPOS Cárdenas
Development organisations	Fundación Produce La Laguna SOMEXAA	Fundación Produce Jalisco COFOCALEC	Fundación Produce Tabasco Fundación Tabasco CFPPET RENAP
Government organisations	SAGARPA La Laguna	SAGARPA Jalisco	SEDAFOP DCyREMA
Total organisations, 46	13	19	14
Total interviews, 64	20	27	17

Fifty-six complementary interviews were conducted in another 14 locations (see Table 4.6) to get a better understanding of the contexts and processes in the regions (e.g. development of DEPAI and GGAVAT groups), and the underlying assumptions of other actors and organisations which have influenced the development of the dairy regions. This is important because the MDS has a national agriculture policy, which is interpreted and implemented differently in the dairy regions depending on their regional structures, their capabilities and certainly their socio cultural and economic institutional set-ups.

Table 4.6 Interviewed organisations in the MDS, supplementary interviews

Main actors/locations	**Mexico City and Estado de México (Cuautitlán, Naucalpan and Texcoco)**	**Veracruz (Coatepec, Tuxpan, Coatzacoalcos, Jamapa, Ozuluama, Cotaxtla and Veracruz)**	**Morelos (Jiutepec)**	**Michoacán (Morelia)**	**Querétaro (Querétaro)**
Milk and dairy processors, main firms	Alpura Nestlé, D.F. LICONSA	Nestlé, Coatepec JAMALAC			
Cattlemen association	CNOG ANGLAC	AGLO UGRSV UGRNV UGRZCEV			
Suppliers of inputs for milk and dairy production	Tetra Pak México		Westfalia Surge		DeLaval
Research institutions	INIFAP, central office Colegio de México	INIFAP, La Posta			
Financial development institutions		FIRA, Veracruz		FIRA central office	
Universities	IIE (UNAM), IIS (UNAM), CIESTAAM, UACh	Universidad Veracruzana			
Development organisations	FAO, SAGARPA IFPRI				
Government organisations	SAGARPA, central office SIAP	SAGARPA and Desarrollo Rural, Veracruz			
Professional organisations	CANILEC AMMVEB	CEMVZV			Asociación Holstein de México
Total organisations, 33	17	12	1	1	2
Total interviews, 56	20	29	1	4	2

Most of the interviews were individual, except for four group interviews, and written notes were taken. Interviews lasted an average of two hours.

The secondary sources of information (b) provided insights on the context and data on capabilities creation and accumulation, which complemented the evidence from the interviews within a triangulation process employed to validate the data collected.

The data were analysed in two stages. Firstly, the written notes from the in-depth interviews were translated and transcribed. This provided a deeper understanding of the roles and interactions (activities/processes/mechanisms) that contribute to the development of capabilities. The empirical information and data were thus classified and transformed into analytical evidence in each case.[168] Secondly, some of the analytical evidence was presented in tabular form based on the criteria for changes in the dairy farms and dairy firms associated with the technological components proposed in Tables 4.7 and 4.8 as explained below.

4.4 Operationalisation of the analytical framework

Operationalisation of the analytical framework sets up the bases to carry out multilevel observations (as proposed by Hekkert, Suur et al. 2007 and Jacobsson and Bergek 2006) by mapping out the following variables:

a) Identification of the structure of the main actors, networks and institutions,
b) Identification of the actors' main roles and interactions, i.e. collective activities/processes/mechanisms that might have triggered learning processes influencing changes in the intra organisational routines and procedures that evolved towards improved and new capabilities of dairy farms and firms,
c) Identification of the particularities of regions and their historical contexts to identify main networks for learning and institutions,
d) Identification of main constraints in the regions that might have impeded and/or delayed capabilities development;
e) Systematic comparison of the regions in terms of capabilities development and associated performance using seven functions and development of sets of specific regional policies to support the improvement of capabilities or the elimination of the constraint to build up capabilities.

[168] The information was triangulated to create robust evidence and control for problems associated with other research and discrepancies among interviewees' statements.

Operationalisation of the analytical framework was done by connecting interactions between firms and other actors, i.e. observable activities, processes and/or development mechanisms (interactions) carried out collectively by the actors in each region, which eventually modified the technological and organisational capabilities of dairy farms and firms (intra organisational capabilities) and capabilities of the region (inter organisational capabilities). This is the theoretical justification in this research for the design and use in the analysis of the main technological components associated with milk and dairy production (see Tables 2.3 and 2.6), because the changes in these components are related to productivity and competitiveness. For instance, from the interviews and literature, we analyse the cluster of activities/processes/mechanisms that contributed to specific changes to improve milk production in farms, i.e. best practice for milking and dairy production,[169] and development of new products and markets (economic indicators of performance of the regions). From an analysis of interactions of actors and the learning mechanisms that led their evolution, we infer functions and dysfunctions in systems, when we compare them with the indicators of performance across the three regions. From them we develop a set of regional policy recommendations, as it will be explained below.

4.4.1 Identification of actors, networks and institutions

The fact that the actors in dairy regions (e.g. farmers, dairy firms, research institutes, universities, suppliers, development organisations, financial organisations, etc.) are present does not mean that *de facto* dairy RISs exist as functional systems. Therefore, in each region, we map out all the relevant actors, technologies and sources of knowledge (this follows the proposal of Malerba for SIS) and identify networks of learning throughout actors' interactions, i.e. formal and informal (Bergek, Jacobsson et al. 2005), and identify their institutional arrangements (e.g. the socio economic and political context of the MDS) following Carlsson and Stankiewicz (1991); for instance, the interactions of farmers and dairy firms, government organisations and dairy farmers and firms and university/research institutions with dairy farmers, etc., directed to

[169] Mexican farmers and dairy firms usually follow Good Manufacturing Practices, GMPs of the FDA. GMPs describe the methods, equipment, facilities and controls for producing processed food. As the minimum sanitary and processing requirements for producing safe and wholesome food, they are an important part of regulatory control for the safety of the nation's food supply. GMPs also serve as one basis for FDA inspections (US Food and Drug Administration) (http://www.cfsan.fda.gov/~dms/gmp-1.html) (July 15, 2007).

specifically change some technological or organisational capabilities (e.g. milk farmers' and dairy firms' interactions and interrelationships), which were influenced by national policies (top-down approach) (Howells 1999; Iammarino 2005) .

The identification of institutions focuses on apparent patterns and norms of social interactions, which influence the decision-making processes of individuals and their organisations (Johnson 1992) in the regions. The purpose here is to map the relevant actors' collective activities/processes/mechanisms that might have led the institutional alignment or misalignment in the dairy regions (von Tunzelman and Wang 2003; von Tunzelmann 2003; von Tunzelmann 2004), or the lack of them which might have led to successful or poor initiatives of firms and other organisations to innovate in the regions (Nelson 2005; Nelson 2006; Nelson 2008) and influenced their performance. Therefore, they eventually influence the functions/dysfunctions in the dairy regions (Bergek, Jacobsson et al. 2005; Edquist 2005; Jacobsson 2005) (e.g. degree of integration of the value chain and expansion of the markets for chilled milk and other dairy products; which is the case for La Laguna).

4.4.2 The micro level analysis of interactions, from organisational routines to capabilities in dairy farms and firms and regions

As proposed by Jacobsson and Bergek (2006), mapping out interactions among actors requires multilevel observations (e.g. farmer to farmer, farmer to firm, farmer to government organisation, etc.) to create the evidence on how these changes happened and what technological and organisational capabilities have changed in the farms and firms and eventually in the region/system, when more dairy farmers and firms carry out similar practices. While most of these interactions are observable over time and thus act as indicators of change, none of them individually provides an unambiguous indicator of capabilities, except for the meso level of aggregation. Thus, observed interactions are seen from a higher level of aggregation in the regional systems, while dynamic capabilities are situated in the cognitive abilities and behavioural routines of specific dairy farmers and dairy processors and within supporting organisations. By clustering several of the interactions over time (i.e. networks for learning), it is possible to develop some indication of learning processes of individual actors, and this higher level of aggregation provides a more feasible vantage point for examining the changes in capabilities and functions. Thus while cognitive and behavioural evolution of individual actors is important, it is largely outside the scope of this research and this evolution can only be inferred from the efforts dedicated to these collective activities/processes/mechanisms.

For identification and analysis of the evolution of capabilities at the micro level in dairy farms and firms, we propose the integration of the value chain in each region as shown in Figure 4.4, which help us to develop analytical constructs (see Tables 4.7 and 4.8) to identify and analyse the main technological and organisational capabilities in the regions.

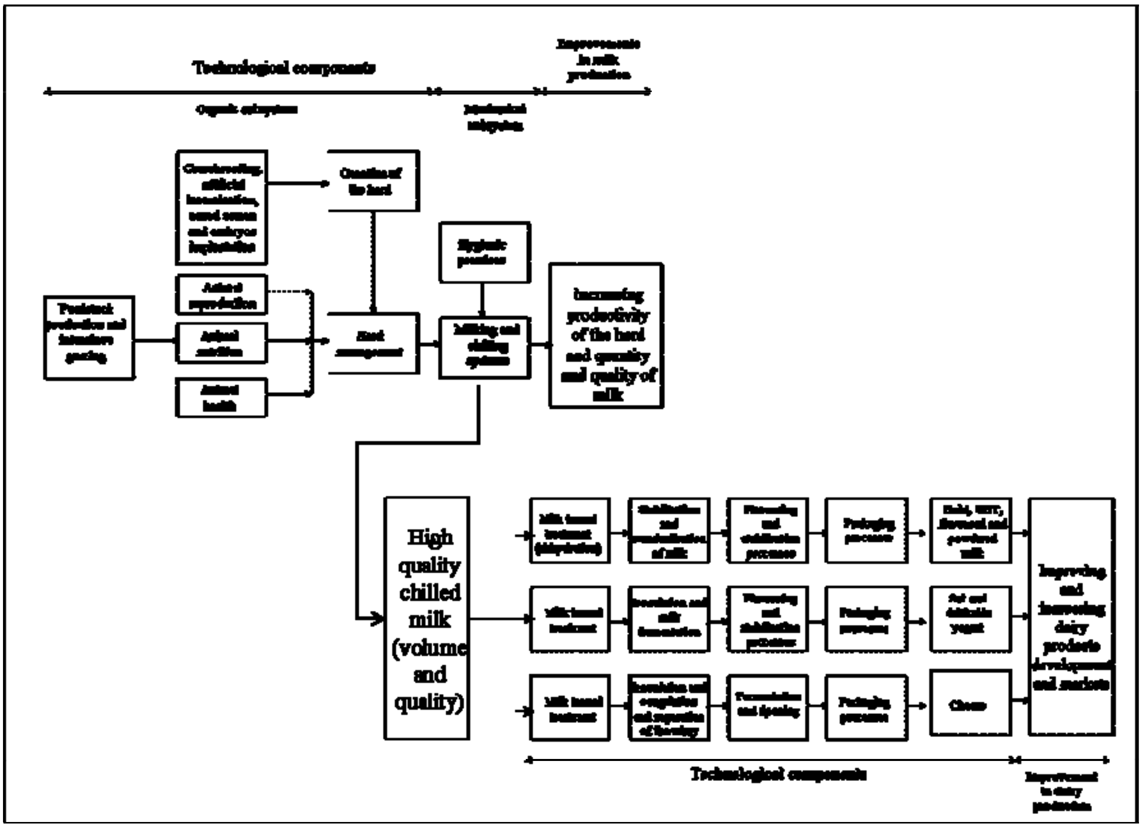


Figure 4.4 Integration of the value chain for milk and dairy production

To observe these changes in capabilities, in Table 4.7, we set up for milk production, in column 1, the technological components based on the specialised milk production system. Column 2 shows the main routines and procedures associated with the technological components of column 1, which could have changed during the period of analysis. Column 3 shows the possible technological and organisational capabilities, which might have evolved based on the changes in the main routines and procedures in column 2. Column 4 lists the aggregated indicators of performance of regions, which are associated with the changes of capabilities of milk production.

Different assemblages of changes in these routines and procedures explain the differentiated incremental innovation processes for milk production in the regions. For instance, improving the genetics of the cows implied increasing use of artificial insemination, which led to changes in the routines regarding cow's heat detection and insemination. The fact that more professionals – veterinarians, animal nutritionists and research institutes gave advice to farmers to improve herd management (i.e. cow's heat detection, artificial insemination, control of diseases in the herd, use of silages and grains, etc.) and farmers adopted the practices, eventually over time; they changed the technological capabilities within farms. When the newly adopted procedures (i.e. routines) for cows' insemination, control of diseases, etc. were widely used across farms in a region, they led the changes in herd management capabilities and eventually changes in the milk production capabilities in a region.

Table 4.7 Milk production capabilities and aggregated indicators of performance

<table>
<tr><th>Technological components</th><th>Types of routines and procedures within farms</th><th>Technological and organisational capabilities evolution</th><th>Aggregated indicators of performance in regions
Extent of the use of technological components of the specialised milk production system</th></tr>
<tr><td>Genetics of the herd</td><td>Use of specialised cows and heifers for milk production
Use of artificial insemination, sexed semen and embryo implantation</td><td rowspan="4">Herd management capabilities

Dairy farming capabilities

Agriculture capabilities to improve production of grains and grazing for feedstock

Organisation to chill milk and commercialise it for industrialisation</td><td rowspan="4">% of the changes in routines and procedures in the region

% of farmers using improved milk production systems

Productivity per cow, litres of milk/day

CAGR of milk production in the region

Changes in the % of market share for milk production

% of chilled milk commercialised for industrialisation</td></tr>
<tr><td>Herd management (animal reproduction, nutrition and health)</td><td>Control of mastitis, brucellosis and tuberculosis
Control of cow's heat and weaning
Design of diets based on feedstock availability and intensive grazing
Agriculture processes for feedstock production and intensive grazing</td></tr>
<tr><td>Milking and milk conservation</td><td>Hygienic practices within the farms: cleaning practices for cows
Use of automated milking machines and closed system to chill milk in tanks within farms and during transportation to dairy facilities</td></tr>
<tr><td>Logistics for collection of milk</td><td>Milk collection systems</td></tr>
</table>

Source: Author's elaboration using data from Table 2.3 and information from interviewees.

For dairy production, in Table 4.8, we set up the technological components based on dairy products and process technologies in column 1. Column 2 shows the types of routines or procedures that might have changed the technological and organisational capabilities of dairy processors in the regions to improve their dairy products and or to produce new ones and expand their markets. Column 3 sets up some of the technological and organisational capabilities based on changes in routines and procedures of column 2. Column 4 sets up some aggregated indicators of performance of the regions, which will be used in the analysis and comparison of the cases.

The innovation of dairy production implies new sets of routines and procedures, which fit with the specifications of the dairy products. If a firm wants to develop a new type of yogurt, the different departments in the firm have to work together to set up a specification of the product and the changes in processes as well as in packaging materials to fulfil the needs of the consumers[170].

Table 4.8 Dairy production capabilities and aggregated indicators of performance

<table>
<tr><th>Technological components based on dairy products and process technologies</th><th>Types of routines or procedures in dairy processing</th><th>Technological and organisational capabilities evolution</th><th>Aggregated indicators of performance in regions</th></tr>
<tr><td>Fluid milk, long shelf-life, UHT and flavoured (smoothies) and powdered milk
Cheese: unripe and mature
Yogurt: stirred, set, drinking, pro-biotic drinks, fruit-on-the-bottom, soft-serve and hard pack frozen, continental, French and Swiss</td><td>Thermal treatment, quality assurance, dehydration and aseptic processes
Ingredient preparation and formulation of products
Stabilisation procedures
Inoculation and milk ripening
Coagulation and curd treatment
Cheese ripening (temperatures and timing)
Fruit preparation and flavouring procedures
Fermentation processes, started culture selection, adaptation and standardisation of cultures
Packaging (shelf-life, materials and processes, aseptic packaging)</td><td rowspan="2">R&D and engineering capabilities for dairy production

Dairy production capabilities

Commercialisation, marketing and branding capabilities

Alliance-making capabilities</td><td rowspan="2">Number and types of dairy products

Number of dairy facilities

Number of markets (distribution centres) in national and international locations

Number of brands

Positioning of firms in the market

Number of foreign alliances</td></tr>
<tr><td>Logistics of dairy product commercialisation</td><td>Design and changes in distribution systems</td></tr>
</table>

Source: Author's elaboration using data from Table 2.6 and information from interviewees.

In the identification and analysis of capabilities in dairy farmers and firms, we tried to identify the main sources of knowledge for innovation, either internal (mainly R&D and

[170] As established in Chapter 1, this research does not provide evidence of the interactions of dairy firms and the distribution channels and final consumers.

engineering departments) or external from interactions with other research organisations as we discussed in the criteria for selection of the theories in section 3.1.

It should be noted that it might be possible to observe learning processes at different levels or units of analysis. However, this research is not a situated firm-level study, (micro level). Some specific examples of dairy firms are provided (e.g. Lala in La Laguna case, 5.1; Lechera Guadalajara and Sigma Alimentos in Los Altos case, 5.2 and Ultralácteos in Tabasco) and at the aggregated level for dairy farms in each region to make the integration of micro and meso levels. However, there are some limitations. For instance, the overall coherence and progress of the analysis cannot effectively address the degree of variability within regions. Thus, it does not indicate whether it would be more effective to focus on reducing variability within the milk production systems in regions or to focus on attempting to stimulate the rate of advance of individual actors. This is an important qualification as it introduces a bias in this research towards adopting the technological package or the Holstein model, involving chilled milk collection and processing rather than a programme of developing high quality ‘raw’ milk supplies in a more homogeneous system with rather different possibilities for processing (e.g. artisan production and rapid consumption). Although the latter route is not likely to be effective, the evidence does not allow it to be discounted as a sustainable alternative because of a lack of observations at a lower level of analysis.

4.4.3 The meso level analysis, from capabilities to functions and dysfunctions in regions

Functions are key processes in a system and are the result of the multiple interactions of actors. Thus, from an analysis of the collective interactions (i.e. activities/processes/mechanisms) observed in the regions, we group them according to their contribution to specific functions or processes reflecting in the processes and interpretations of the indicators proposed by Bergek, Jacobsson, et al (2005) and analysis and interpretation of the cases of Jacobsson and Bergek (2006) in a developing context (see Table 3.3). A sample of activities/processes/mechanisms that this research proposes that may have contributed to changes in capabilities and eventually functions in regions is summarised below in Table 4.9 and will be tested in this research. An interpretation of the function ‘entrepreneurial experimentation’ is based on the collective interactions of actors (activities/processes/mechanisms) to either a) develop new competitors, b) develop new firms providing complementary services for the sectors, or c) expand to other locations by building up new facilities and/or acquiring firms, since no new technologies are developed in the sector.[171]

Table 4.9 Activities/processes/mechanisms and functions in systems

Activities/processes/mechanisms	Systems functions
1. Carrying out R&D activities in firms, universities, research institutions and organisations 2. Developing human capital through education and training in specific technological fields, entrepreneurial, management, finance, etc. 3. Providing consultancy and other professional services including suppliers' technology transfer by selling capital goods, technology and market services 4. Encouraging a user-producer relationship under different partnerships (e.g. alliancing, venture capital, FDI, etc.)	Creating and diffusing knowledge
1. Envisioning the future of the sector (economic and social impact) 2. Creating and changing institutions to influence innovation process such as IPR laws, environment and safety regulations, etc.	Driving research process
1. Setting up new competitors and/or firms 2. Setting up firms to supply complementary services for the industry 2. Expanding facilities to other locations and/or acquiring firms	Entrepreneurial experimentation
1. Articulating demand and supply of goods and services to serve the sector 2. Evolving the structure of the industry, horizontal and vertical integration	Facilitating the formation of markets
1. Facilitating information and knowledge exchange 2. Networking through markets and integrating new knowledge from outside of the systems to innovate 3. Promoting the entrance of complementary technologies and services	Creating positive externalities
1. Supporting social acceptance and compliance with relevant institutions of new products and technologies 2. Legitimating new products, new technologies or new market practices	Legitimation
1. Supporting development programmes for modernisation, acquisition and technology transfer. 2. Supporting investment in projects to build infrastructure for industrial advancement. 3. Developing complementary assets for network formation (e.g. ICT projects, general purpose projects, etc.) 4. Supporting training programmes	Mobilising resources

Sources: Author's elaboration.

Functionality and dysfunctionality refer to the degree of coherence or incoherence (alignment or misalignment) of the processes (functions) in the systems that allowed the

[171] This interpretation is supported by Bergek, Jacobsson et al. (2008, p. 416), Hekkert et al (2007, p 421) and Jacobsson and Bergek (2006, p 694) for the following reason. In a traditional sector that uses sets of well-developed technologies, innovation sources come from a great variety of technological areas (e.g. agriculture and veterinary science, genetics, biotech, new packing materials, ICT, etc.) to improve processes and products. Therefore, entrepreneurs have a central role in a well-functioning innovation system. Their role is to turn the potential of new knowledge, networks, and markets into concrete actions to generate and take advantage of new business opportunities either as new entrants that have the vision of business opportunities, or as incumbent companies who diversify their business strategy to take advantage of new developments. Therefore, they are able to enhance their knowledge development in terms of application knowledge 'downstream' (Jacobsson and Bergek 2006, p 694).

effectiveness or ineffectiveness of the actors to achieve and sustain economic advance via capabilities building following a modernisation process, which includes the use of a specialised milk production system and the development of dairy products following international trends. Dysfunctionality is then referred to as learning failure using the language of Malerba (1997) for regional capabilities building. Then, *dysfunctions* are inferred from analysis of the opinions of interviewees on which the cases are based and previous literature of what has not been achieved for each of the functions, although some activities, processes and mechanisms have collectively been done to change specific areas in the regions to modernise the system, but attainments fall short of the expectations of specific actors involved in them. Dysfunctionality also is inferred when there were blocking mechanisms and constraints in the regions that impede the development of regional capabilities (see subsection 4.4.4). Thus, higher rates of economic performance in regions are associated with higher accumulation of regional capabilities. The opposite, lower rates of growth in the regions are associated with limited or poor development of regional capabilities. [172]

From the analysis, the quality of activities/processes/mechanisms and the degree of attainment of firms' economic performance within regions and across regions (e.g. growth rate of milk production, number of dairy products, etc.), we can infer that sector-specific regional capabilities have accumulated in three different levels following the proposal of Zollo and Winter (2002) and Winter (2003). They are classified as: a) *basic capabilities* implying that the regional actors have changed some of the technological and organisational routines; however, no major changes have been observed in the performance of milk and dairy production (i.e. growth rate of milk and dairy production and development of new products lower than the country average); b) *operational capabilities* implying that regional actors have changed some of the technological and organisational routines and improved performance in milk and dairy production (i.e. growth rate of milk and dairy production and development of new products closer to the country average); and c) *strategic capabilities* implying that regional actors have changed some of the technological and organisational routines and significantly improved performance in milk and dairy production (i.e. growth rate of milk and dairy production and development of new products higher than the country average) and

[172] This is consistent with Bergek, Jacobsson et al. (2008, p 410) of capabilities failure related to actors.

expanded their markets to *national and international.* It is thus possible to infer a functional pattern accomplished in regions (Jacobsson and Bergek 2006). A cross-case analysis will be carried out in Chapter 6.

4.4.4 Actors' blocking mechanisms and constraints for capabilities development

In addition to identification of the actors' activities/processes/mechanisms that have led to capabilities development in the regions, this research also identifies the blocking mechanisms and constraints (i.e. weaknesses in the system) (as proposed by Jacobsson 2005) that might have blocked or delayed the responses of regional actors for building capabilities. These constraints were classified as follows:

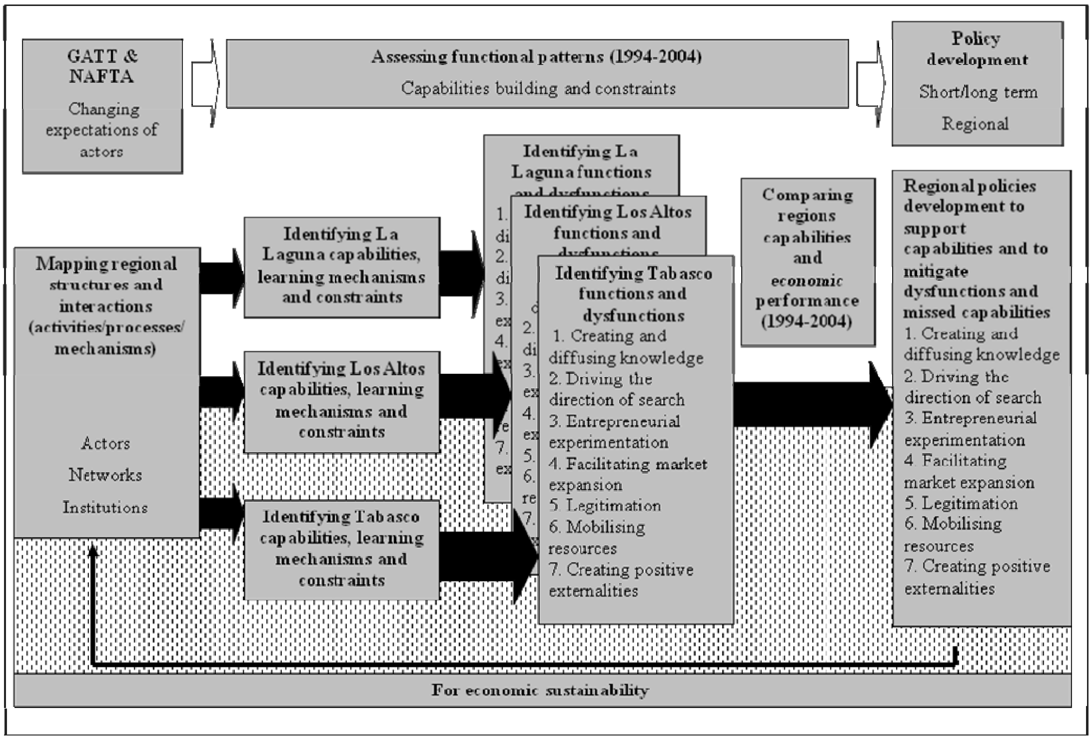
1. socio-cultural constraints, which refer to the social and cultural behaviour of the actors in the regions, which may have restricted the development of the dairy region;
2. economic constraints, which refer to the availability of economic resources for the development of the sector, either public or private;
3. environmental constraints, which refer to the geographical factors in the region that affect milk and dairy development;
4. education and research constraints, which refer to the state of education and research in the region that might affect dairy development

These constraints are associated with dysfunctions in the regions and could be addressed in future policy recommendations (Jacobsson and Bergek 2007; Bergek, Jacobsson et al. 2008) together with misalignment in the dairy regions (lack of evolution of networks and institutions (von Tunzelman and Wang 2003; von Tunzelmann 2003; von Tunzelmann 2004), which might also have led to dysfunctions in the dairy regions (Bergek, Jacobsson et al. 2005; Edquist 2005; Jacobsson 2005).

4.4.5 Identifying key policy recommendations to improve capabilities development

The extent to which regional capabilities developed and fulfilled the seven functions provide the basis for policy making design (Bergek, Jacobsson et al. 2008). In order to do so, we analyse the outcome of the analysis of the structures of the dairy regions and their dynamics during the 1994-2004 period on the premise that capabilities accumulation largely determines effectiveness (functionality) or ineffectiveness (dysfunctionality) in increasing milk production and new dairy products and new markets. From this analysis and considering the national policies of the MDS (i.e. context dependent), this thesis proposes the development of regional policies that aim to support capabilities development and/or mitigate the constraints to build capabilities in the short term (ST) and long term (LT). ST is 1-6 years – it assumes that infrastructure and institutions already exist; LT is over 6 years – it assumes that there is a need for infrastructure and further changes in institutions. This timing was estimated taking into account the periods of implementation of Alianza para el Campo as an example of a general policy for the MDS and with 6 years being the maximum presidential term, implying a possible coherence in the policies and activities of the actors. However, these policies can be modified if a continuous process assessing the actors' collective activities/processes/mechanisms is carried out (as it has been suggested by Lindblom 1959), from a bottom-up understanding of the interactions of the actors in the regions (see sections 6.4 and 6.5), which could affect regional policies and top-down national policy implementation.

In brief, this section has provided the way to operationalise the concept using its analytical framework. A summary of analytical framework operationalisation for the cross-case study is depicted in Figure 4.5.



Source: Author's elaboration.

Figure 4.5 Operationalisation of the analytical framework to observe the evolution of sector-specific regional capabilities

4.5 Scope of the research and constraints to collecting the evidence for building cases

Using a multiple case comparison, a phenomenon observed (i.e. development of capabilities) in one region raised questions about why this did not occur in another or occurred in a different way; therefore, we provide evidence to generalise the findings to other dairy regions. However, it is important to note that the outcome of regional dairy systems' capabilities creation is likely to be affected by many conditions or externalities, which cannot be captured by this analytical framework (e.g. the effects of other economic sectors and factors in the regions). Therefore, the dynamics of the regions might shift to the production of other agricultural or industrial products. We argue that even with the externalities that are present, some regional capabilities are already *embedded* in the system/regions (e.g. organising the integration of networks for learning, INIFAP research capabilities and GGAVATT groups), which might be helpful for other agribusinesses and sectors.

The main constraints to building up the cases are:

a) There were no direct observations of the changes in routines carried out within farms and firms; therefore, the analysis addresses the meso level of aggregation. Previous researchers in dairy regions identified these changes. Triangulation of the findings with interviewees confirmed these changes in the organisations and the systems.

b) Identifying activities/processes/mechanisms that supported capabilities development and analysing their contribution to specific functions was an important challenge, because of the nature of the capabilities, which might have contributed to more than one function or dysfunction. However, since activities/processes/mechanisms are locally situated and had individual histories of involved actors, we identified associated functions when several interviewees agreed in one or another. Further micro-level research should be suggested to confirm these findings especially for further insights of the learning processes and to determine the agency of the actors.

c) Local meanings and individual histories can only be partially captured in fieldwork. However, acknowledgement of the existence of specific activities/processes/mechanisms by interviewees did shed light on specific policies to address long-term economic sustainability of the dairy regions;

d) The seven functions approach; although it seems to be useful for carrying out a systemic comparison of the evolution of regional capabilities, further interpretation of activities/processes/mechanisms that led functions is needed (see Table 4.9). For instance, in the case of entrepreneurial experimentation, an interpretation has to be made in order to apply it to a sector analysis. However, this was expected, since the framework is tested and there are no former indicators to analyse functions in regions in agribusiness;

e) Limited budget for the fieldwork did not allow a second round of interviews/visits to stakeholders to test the investigator’s accuracy in collecting evidence and interpreting this evidence to infer functions/dysfunctions in the regions.

4.6 Summary

This chapter has outlined a theory-based concept and framework, which has been made operational for application to a multi-case studies analysis. It refers back to the research motivation to understand how regional capabilities in the Mexican dairy regions evolved as an alternative explanation to the market-incentive and market-failure approach of neoclassical theory.

A system-learning approach proposed in this section explains performance and focuses on systemic success or failure as a result either of the creation or of the failure of the interactions of actors to create capabilities, which will be tested in the cases in Chapter 5. While market incentives and market processes are present in capabilities creation processes, they are not central to them for this analysis. In short, actors' interactions, i.e. collective activities/processes/mechanisms can be effective or ineffective learning ways to build capabilities and to make systems functional and/or dysfunctional.

The analytical framework proposed for this research articulates the coevolution of inter and intra organisational routines into regional capabilities, micro-meso levels of aggregation, which are represented by functional/dysfunctional patterns of regions to build capabilities. Evaluation of functions suggests conclusions about performance beyond the simple indicators provided by output and productivity. Assessment of the functions in regions also provides insight to develop regional policy recommendations. Finally, this analytical framework allows us to explore how and why other supporting actors' activities can impede or delay learning processes in such systems, taking learning processes as the core of regional capabilities development.

The multiple-case research method will be used: first, to provide empirical grounding from operationalisation of the analytical framework, although it is not possible to standardise a measure-based approach for diagnosing systemic failure; second, to explain why and how the dairy regions were selected to empirically ground the concept and the analytical framework; and third, to explain the procedures used to collect and analyse the empirical data that constitutes evidence for the systemic explanations proposed by this research. These elements define the scope of the research method and identify the constraints to building the cases.

We claim that applying this analytical framework in a multi-case research method makes it possible to explain the economic performance in regional dairy systems based on differences in development of capabilities in regions to reach exemplary outcomes, taking into account the differences in climatic conditions, history and technological path. This constitutes advancement to the RIS and regional capabilities approaches and an elaboration of possible explanations of system performance, an area of research where more evidence is required due to the diversity and heterogeneity of the actors, their interactions and their institutional set-ups. The use of capabilities as the micro foundation mechanisms for functions provides insights at different levels of analysis, i.e. firms/organisations and regions, of the effectiveness and/or ineffectiveness of policy implementation. The ultimate aim of this research is to provide a better understanding of capabilities evolution with top-down implementation of policies, and thus to inform the policy making process aimed at supporting long-term economic sustainability of dairy regions in the MDS.

In Chapter 5, we describe the individual case studies (sections 5.1, 5.2 and 5.3); Chapter 6 provides a cross-case analysis and draws main findings, policy implications and conclusions, which will be further discussed in Chapter 7 along with some suggestions for future research.

Chapter 5. Capabilities building in the MDS: Evidence from the dairy regions

This chapter provides evidence for the evolution of regional capabilities in selected dairy regions of the MDS. The reason for multiple case studies is to drive a crosscutting comparison of the regions using the analytical framework developed in Chapter 4 to identify and analyse similarities and differences of capabilities building. As discussed previously, collective activities, processes and mechanisms influence the capabilities building of actors and have the potential to lead to different economic outcomes. The results of analysis of these collective activities, processes and mechanisms provide a basis for specific regional policies to improve capabilities for economic sustainability of the dairy regions in the long term. Chapters 6 and 7 discuss the results of these activities, processes and mechanisms and suggest some policy recommendations.

Chapter 5 has four main sections. Sections 5.1, 5.2 and 5.3 respectively describe the regional cases: La Laguna dairy system, Los Altos dairy system and Tabasco dairy system. Each case is presented using the same subsection structure. The first subsection presents particularities of the dairy region and its historical context before and at the point of NAFTA’s enactment. The second subsection presents the structure of the dairy farmers and dairy firms and explains how the interactions among them influenced the integration of their value chains and contributed to changes the technological and organisational capabilities of those firms. It discusses how other organisations influenced the integration processes and which collective activities, processes and mechanisms triggered learning supporting the evolution of these intra organisational capabilities in the regions and creating inter organisational capabilities in the regions. This analysis includes:

(a) how dairy farmers integrate agriculture and dairy farming technologies and practices to modernise their units of production and eventually construct networks of milk suppliers of high quality chilled milk based on the technological components of the specialised milk production system (see Table 4.7);

(b) how dairy processors secure their milk supplies and create capabilities to produce new dairy products to expand their markets based on the technological components of dairy production (see Table 4.8);

(c) how the network of suppliers (national and international) of technologies, inputs and services for agriculture and dairy production have influenced the creation of capabilities to modernise dairy regions;

(d) how sources of finance have supported the upgrading of the dairy infrastructure and the operation of the dairy regions as conditions for the development of capabilities;

(e) how research organisations and universities have helped to update actors' capabilities to enable better integration into the value chain; and

(f) how the different roles of other private and public regional organisations have contributed to the development of capabilities.

The third subsection assesses the role of the actors in building capabilities and summarises the capabilities developed and accumulated and links them with the region's economic results. It also identifies the blocking mechanisms and constraints experienced in the evolution of capabilities in the region and summarises the activities/processes/mechanisms (i.e. collective interactions) that contributed to capabilities and eventually to functions (and dysfunctions) during the period of analysis.

Finally, section 5.4 summarises the main findings of the dairy regions and introduces the cross-case analysis which is conducted in Chapter 6 and provides the basis for discussion of the main areas for development of policies for sustainability of the dairy regions.

5.1 Arid and semi-arid regions and the intensive milk production systems: the case of La Laguna dairy region

La Laguna region was formally established as a political and economic jurisdiction by a decree in 1977 based on its rapid economic growth, which was supported by the extension of the railway network to connect it to the main economic centres of Mexico City, Monterrey and Ciudad Juárez.[173] La Laguna has been an attractive economic agriculture region since Spanish colonisation when cows and other domestic animals

[173] Ciudad Juárez is one of the most important economic Mexican cities on the border with the US.

were introduced. It is also an important mining area and has a major chemical industry and most recently a 'maquila' industry[174] for textiles (Salas Quintanal 2002, p 142)

Dairy production in the region started in the early 1950s in response to the agricultural crisis created by the collapse of the international price for cotton, the region's main crop at the time (del Valle Rivera 2000). Currently, most dairy farms use intensive milk production systems; and some farms have reached yields per cow (litres of milk per day per cow) similar to those achieved by dairy farmers in California, Arizona, and Israel from where the model was adapted (García Hernández, Martínez Borrego et al. 1999; Madero Gámez 2005). La Laguna dairy farms are well integrated with the dairy processors Lala and Chilchota, which take their high quality chilled milk. Lala and Chilchota have grown fast and become leaders in the national market for pasteurised milk (Lala) and cheese (Chilchota).

A key feature of La Laguna is its availability and use of water. The region has a well-developed irrigation system using water from two large reservoirs, Lázaro Cárdenas and Francisco Zarco, and from a series of wells. However, the main threat to agriculture and dairy production is a water supply based on high costs of water due to the energy required to pump it to irrigate the land and for use on the farms to clean and cool the cows to improve their productivity. The increasing volumes of water required for agriculture have produced competition with water supply to urban areas (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000; García Hernández, Aguilar Valdés et al. 2005). Water supply problems have been exacerbated by the arsenic content in well water, which is an indication that these water sources are reaching exhaustion and could potentially contaminate urban water supplies, crops and eventually milk (Salas Quintanal 2002; Martínez Borrego, Salas Quintanal et al. 2003).

So far, the higher water costs for milk production have been offset by higher productivity, which explains the success of the region. However, the cost structure of the region is a potential vulnerability. If other regions are able to increase productivity without incurring rising input costs, La Laguna will become less competitive. Another problem lies in the increased production of manure and urine and their potential to

[174] 'Maquila' is the name for a customs arrangement in which the inputs used to produce exported goods are not assigned custom duties.

pollute water and air and to affect the development of other crops and to contaminate wells (Salas Quintanal 2005).

5.1.1 The success of La Laguna: From cotton to milk production, and NAFTA

During the period from the *porfiriato regime* up to the Mexican Revolution (1910-1917), members of La Laguna's elite were owners of large areas of agricultural land (also called 'latifundios'), farmers (also called 'terratenientes', 'hacendados' or 'latifundistas'), and a small wealthy urban population which included some foreigners. This elite was greatly outnumbered by a large and poor peasant population with few people between these extreme economic groups. This disparity in wealth and land tenure was one of the main factors that triggered the Mexican Revolution led by Francisco I Madero (President of Mexico, 1911-1913), during which uprising the peasants demanded a re-distribution of the land. However, it was not until the Cardenista period (1935-1940)[175] that a real re-distribution of land took place with the emergence of small landholders and the formation of portions of common land 'ejidos' owned by groups of peasants called 'ejidatarios'. 'Ejidos' were seen as the means of organising land tenancy and use that would reach the economies of scale[176] required for cotton production in La Laguna (Salas Quintanal 2002) and for other crops (e.g. maize and sugar) in other parts of Mexico.

The pattern of land ownership based on small landholders, 'ejidos', alongside the existing large land owners, increased cotton production, which attracted investment from foreign and regional industrialists (Salas Quintanal 2002, p 137). The heterogeneous rich elite established a cotton processing industry, which was accompanied by the creation of new public organisations and institutions that improved irrigation and provided economic resources, education and technologies for agricultural modernisation. In the early 1950s, cotton production in La Laguna declined following a collapse in the international cotton price which was amplified by the Mexican government's protectionism of the textile industry (Salas Quintanal 2002, p 160).

[175] In this period ruled by President Lázaro Cárdenas, more than 20 million ha were allocated to about 11,000 'ejidos' populated by some 770,000 'ejidatarios' (Salas Quintanal 2002, p 159).
[176] This land ownership regime was modified in 1991 by then President Carlos Salinas (Austin, Chu et al., 2004). This gave those 'ejidatarios' who could prove their rights to the land freedom to use and sell it to increase its efficiency of use and to attract investment. This was one of the most important changes in Mexico's agrarian history since the Cárdenas period (Salas Quintanal, 2002, p 161).

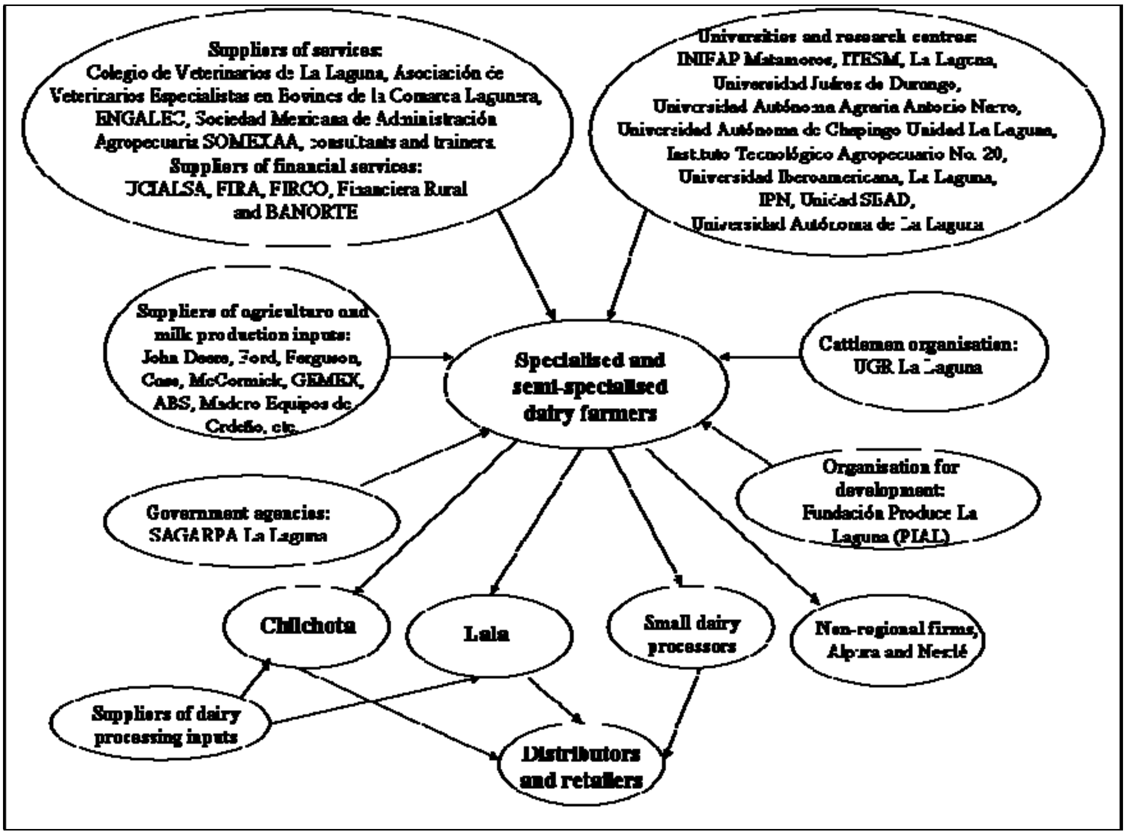
Market conditions were further affected by bad weather, the spread of cotton blight and increased imports of other fibres that led cotton farmers to switch to more profitable markets, i.e. milk production (García Hernández, Martínez Borrego et al. 1998; García Hernández, Martínez Borrego et al. 1999).

Milk production in La Laguna, as an innovative process, was influenced by the example of the Green Revolution, which prompted dairy farmers to aim to achieve global standards (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000; Salas Quintanal 2002). The industrial transformation of dairy production followed two stages, in which government had an important role: first, internationalisation, when the government compensated farmers for the decline in the demand and international prices for cotton. The response to internationalisation also led to a support programme in 1966 for acquiring specialised dairy cows (i.e. Programa Nacional de Ganadería) and for modernising crop agriculture for the production of forage for milk production. Increased use of specialised cows and complementary technological components (see section 2.3) led to the establishment of a technological package, i.e. the Holstein model, in the 1970s. Several authors agree that the second stage or globalisation started with the development of a modern dairy industry in the middle of the 1980s when Mexico joined GATT and the ISI regime ended (García Hernández, Martínez Borrego et al. 1999; Martínez Borrego and Salas Quintanal 2002; Salas Quintanal 2002). By that time, La Laguna milk and dairy production was well-developed and further modernisation was supported with economic resources by the support programmes PROCAMPO in 1986 and later on by Alianza para el Campo from 1995.

It has been argued that cotton production and dairy seem to have followed similar paths of development. Both emerged in response to a growing demand for raw materials (i.e. cotton fibre and milk). They relied on government support to create the economic environment and infrastructure to attract resources to the region and were highly dependent on foreign technologies.

5.1.2 Structure of La Laguna dairy system and actors' roles in the evolution of capabilities

The dairy system of innovation in La Laguna can be seen as the integration of large specialised dairy farms with a few groups of semi-specialised and family farms, integrated mainly by the regional dairy firms, i.e. Lala and Chilchota, and supplying milk to a few small dairy processors and other large non-regional dairy firms, i.e. Alpura and Nestlé. Private and public organisations influenced the integration of dairy farmers and processors as depicted in Figure 5.1.



Source: Author's elaboration.

Figure 5.1 La Laguna dairy system of innovation

The following sections explain how dairy farmers and processors evolved their capabilities, which led the exceptional growth and success of La Laguna dairy region.

a) Evolution of capabilities of the networks of dairy farmers in La Laguna

Milk production started with a group of 149 dairy farmers who in 1949, joined to form a credit union (now UCIALSA[177]) which could finance a pasteurisation facility, Planta Pasteurizadora Laguna (Salas Quintanal 2002, p 171). Until the early 1980s, the structure of milk production consisted mainly of large farmers with updated technologies that integrated one group of 'ejidatarios' who produced forage crops and another group of 'ejidatarios' supported economically by FIRA and BANRURAL, who produced milk in collective farms. The latter group had a lower technological level and some of them at the beginning of the 21st century were still struggling to achieve the milk quality standards demanded by the large dairy firms (Salas Quintanal 2002; Martínez Borrego, Salas Quintanal et al. 2003). By 1983, it is estimated that there were approximately 460 farms, 315 of which produced 90% of the milk processed by Lala (i.e. 159 private large farmers and 156 collective farms from 'ejidatarios') and 145 small family farmers (i.e. 'productores de traspatio'), which produced the other 10%. In 1986, approximately 30% of the collective farms and small farmers were profitable, the other 70% had financial problems and many fell into bankruptcy and were integrated into the value chain to produce forage for the large farmers in the following years (Salas Quintanal 2002, p 185) until the time of the field work (Aguilar Valdés 2005; Luévano González 2005; Salas Quintanal 2005).

The globalisation process resulted in significant changes in the region, such as consolidation of the large network of suppliers of inputs for agriculture and milk production (e.g. the production of feedstock, the supply of chemicals and drugs, semen, spare parts for agriculture, importers of machinery and equipment, etc.). Along with the dairy processors, they pushed the intensive use of foreign technologies for agriculture and milk production and promoted vertical and horizontal integration that led to a substantial increase in the production of high quality chilled milk. This attracted more resources from government through UCIALSA, FIRA, and PROCAMPO/Alianza para el Campo to increase the size of the specialised herd and modernise the dairy firms (Martínez Borrego and Salas Quintanal 2002; Salas Quintanal 2002).

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[177] The origin of UCIALSA was the credit union, Unión de Crédito de Productores de Leche de Torreón, which became the Unión de Crédito Industrial y Agropecuario de La Laguna, SA de CV (UCIALSA) in 1975.

In the period 1997-2002 after NAFTA, the number of family farms in the region increased (see Table 5.1).[178] However, the specialised large farmers still owned approximately 95% of the herd and produced 96% of the value of milk production (Garcia Hernandez and Aguilar Valdés et al. 2005, p 147). Small dairy farmers and 'ejidatarios' accounted for the remaining production in family systems. It should be noted that most of the farms are concentrated in five municipalities (out of 15), and account for more than 98% of the region's milk production (Salas Quintanal 2002; García Hernández, Aguilar Valdés et al. 2005).

Table 5.1 La Laguna milk production systems, main features

	1997			2002		
Technological level	**Family**	**Specialised**	**Total**	**Family**	**Specialised**	**Total**
No. of farms	76 (20%)	297 (80%)	373 (100%)	286 (49%)	301 (51%)	587 (100%)
No. of cows in production	12,165 (7%)	157,552 (93%)	169,717 (100%)	13,720 (5%)	236,830 (95%)	250,550 (100%)
Average of cows in production/farm	160	530	455	48	754	802
No. of producers	609 (38%)	965 (62%)	1,574 (100%)	1,277 (60%)	855 (40%)	2,132 (100%)
Labour	Family	Contracts		Family and contracts	Contracts	
Milking system	Manual and mechanical but not integrated	Mechanical and integrated		Manual and mechanical and some integrated	Mechanical and integrated	
Forage quality	Medium	Good		Medium	Good	
Sheds	Rustic	Modern		Rustic	Modern	
Management capacity	Low	High		Low	High	
Productivity per cow, litres per day	17	26		<25	>25	

Sources: Author's elaboration of data from Salas Quintanal (2002) p 201 for 1997; and García Hernández, Aguilar Valdés, et al. (2005) p 147 for 2002.

According to Salas Quintanal (2002), there is increasing use of technology on farms to consolidate the intensive milk production system. His research found that in 1997-1998 the implementation of new dairy farming practices improved the productivity of the cows from an average of 17 to 26 litres per day. Almost 98% of the milk produced in these years was of high quality with less than 6% sold without chilling (Martínez Borrego and Salas Quintanal 2002).

[178] As previously noted, the direct effect of NAFTA on the dairy industry was deferred until 2008. However, from 1994, many indirect effects began to operate, e.g. import duties on feed, equipment and other inputs as well as displacements from other agricultural activities.

Several interviewees stated that the implementation of technology in dairy farms has increased since 2002. By 2005, productivity per cow had reached between 30 and 35 litres per day; and less than 2% of the milk in the region was commercialised without being chilled (García Nuñez 2005; Madero Gámez 2005). However, the average yield per cow in La Laguna is lower than in similar systems in other countries[179] (Martínez Borrego and Salas Quintanal 2002; Salas Quintanal 2002).

In addition to increased use of technology following the intensive model, there has been a trend since NAFTA to 'professionalise' farmers through education and recruitment of experienced professionals and 'mayordomos' or farm managers. It has been suggested that some of the older farmers' agricultural experience was perhaps transferred to a younger generation, which is better educated (e.g. veterinarians, agronomists and business graduates). The most recent generation includes business graduates who hire professionals (e.g. veterinarians and agronomists). Many of these younger managers have been trained in milk production techniques in Mexico and abroad. However, some dairy farmers are still resistant to the need to employ higher educated professional managers, whose incentives for long-term employment on the farm may be small.[180] This has resulted in some well qualified managers and labour moving to other dairy regions and threatenining the labour market of the region (Aguilar Valdés 2005; Luévano González 2005).

It has been argued that in order to remain in milk production, many 'ejidatarios' and small farmers, weathering the 1996 economic crisis, developed associations of producers (e.g. rural units of production, cooperatives, etc.) and others changed to produce forage for milk production (i.e. alfalfa and grains) (Martínez Borrego and Salas Quintanal 2002; Salas Quintanal 2002). However, some of them have left the activity and created some social problems in the regions, because they were not able to engage in other economic activities (Aguilar Valdés 2005; Luévano González 2005).

[179] This is a controversial issue because some regional farmers confirm that their average production per cow is similar to that in other countries and that their farm profitability has improved. However, there are no official data to support these claims.

[180] Interviewees in all the regions stated that dairy farm labour is a relentless fulltime activity and thus the incentives for labour to stay on need to be substantial. It has been argued that labour prefers to work in 'maquilas' because they offer benefits and 40-hour working weeks, although they pay lower basic wages than dairy farms.

Table 5.2 shows a summary of the main capabilities developed for milk production, mechanisms for capabilities development that were carried out by farmers and led to the improvement in productivity of the cows (17-26 l/day/cow) and the integration of the value chain that commercialised 98% of chilled milk for industrialisation.

Table 5.2 La Laguna milk production capabilities and development mechanisms

Capabilities	Development mechanisms
Technological capabilities to improve the genetics of the herd	Almost 100% of farmers have specialised milk cows, 82% of farmers use artificial insemination and other practices such as transplant of embryos, and sexed semen practices
Technological capabilities to improve herd management	88% having integrated forage production and 68% having integrated silage production 79% using regular professional assistance for herd management 59% using regular technical assistance from agro industries 44% using computerised systems for herd management 59% having designed sheds for animal comfort[181] 85% milking twice per day, and 15% thrice
Technological capabilities to improve milking systems and hygiene practices	79% using mechanical milking, and 21% manual 100% using cleaning practices for udders during milking and 44% stimulating the udders
Organisational capabilities to integrate farmers to chill milk and commercialise it for industrialisation	Setting up the largest chilling infrastructure supported by dairy farmers, Lala and Chilchota to commercialise 98% of chilled milk

Source: Author’s elaboration of data from Salas Quintanal (2002).

b) Evolution of capabilities of La Laguna dairy processors: Lala and Chilchota

The structure of dairy processors in La Laguna is straightforward. In 2001, Lala was the leading firm, accounting for approximately 66% of the total collection of milk followed by Nestlé (15%), Alpura[182] (10%), Chilchota (4%), and some small dairy processors, who accounted for the remaining 5% of output (García Hernández, Aguilar Valdés et al. 2005, p 156).

From 1996 to 2001, the dairy industry in La Laguna increased its processing capacity by approximately 3.6 times, an average growth of 29% per year, and doubled its collection of milk at a rate of 15% per year. Plant capacity utilisation increased from an

[181] This involves spraying the cows using misters, to alleviate ‘heat stress’ which reduces milk yields (García Hernández, Aguilar Valdés et al. 2005).
[182] Nestlé and Alpura have no dairy facilities in La Laguna; the milk they collect is transported to their facilities in Estado de Mexico (Alpura) and Los Altos in Jalisco (Nestlé).

average of 26% to 81%.[183] In 2002, dairy firms produced approximately 80% of pasteurised and UHT milk and 20% of other dairy products by volume. The region has the best infrastructure for the transport of raw fresh milk and distribution of dairy products, and serves the national market via a distribution system of mostly small family-operated shops, 70%, and 30% to big retailers (García Hernández, Aguilar Valdés et al. 2005, pp 159-160).

Lala (Grupo Industrial Lala, SA de CV) is one of the 100 largest Mexican corporations and one of the 300 largest in Latin America. Its sales value in 2004 was Pesos 20,589 million, a 15.8% increase on the previous year (Expansión Editor 2005) and was approximately Pesos 24,000 million in 2005 (Expansión Editor 2006), a 16.6% increase on 2004.[184]

The origin of Lala was Planta Pasteurizadora Laguna set up in 1949. Currently, the corporation is composed of 29 firms, which includes 16 dairy facilities[185] and complementary inputs and services such as packaging materials, transportation and financial services (i.e. UCIALSA) (see Table S5.1). More than 22,000 people participated in the production and distribution of approximately 4.0 million litres of milk per day in 2005,[186] making Lala comparable in size to other MNCs.[187] This processing volume has doubled since 1994[188] and demand is satisfied by imports of NFDM.[189]

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[183] Author's estimations based on information for 1996, from del Valle Rivera and Alvarez Macías (1997) p 11; and for 2001, from García Hernández, Aguilar Valdés et al. (2005) p 155.

[184] Lala's revenue is derived as follows (approximately): 40% from pasteurised milk, 30% from UHT milk, 20% from yogurt and 10% from cheese (Arista Puigferrat 2005; Arrieta González 2005).

[185] The dairy facilities are located around Mexico in Aguascalientes (Aguascalientes), Acapulco (Guerrero), Durango (Durango), Ciudad de México, Guadalajara (Jalisco), Irapuato (Guanajuato), Mazatlán (Sinaloa), Mérida (Yucatán), Monterrey (Nuevo León), Tecate (Baja California), Tizayuca (Hidalgo), Torreón (Coahuila), Naranjos and Veracruz (Veracruz).

[186] Based on information on Lala's web site which indicates 4 million litres per day: See http://www.lala.com.mx/nuestra_empresa/frame_master_nuestra.html (March 15, 2006).

[187] It is estimated that the volume of production is close to that of the larger MNCs such as Arla, Melkuni and Dean Foods (Hernández Astorga 2005).

[188] Estimations from Martínez Borrego, Salas Quintanal, et al. (2003), p 118, at 1.8 millions of litres per day in 1994.

[189] Some interviewees felt that Lala was exceeding its quota of imported NFDM since NAFTA, because it was cheaper than fresh milk in the regional market. To the extent this is true, it would create a surplus in the region, reducing prices of fresh milk and possibly causing losses for dairy farmers, especially smaller ones. This might explain the collection of milk by Nestlé and Alpura. On the other hand, others argued that Lala's core business is dairy production. Therefore, it has the right to import cheap NFDM.

Lala strengthened its strategies for modernisation and expansion since NAFTA following a vertical and horizontal integration with dairy farmers and other suppliers of inputs and technologies. This allowed it to upgrade milk and dairy technologies to achieve one of the highest qualities for raw fresh milk and dairy products in the country (del Valle Rivera 2000; García Hernández, Martínez Borrego et al. 2003; García Hernández, Aguilar Valdés et al. 2005; Hernández Astorga 2005). It has also updated its information systems, which provide real-time data on milk collection and consumption levels in regions, cities and specific locations which act as inputs for planning production and distribution (PRNewswire 2000; Chavarría Alarcón 2005). This has reduced the firm's transaction costs and made it the leader for packed fresh milk (García Hernández, Aguilar Valdés et al. 2005).

Lala´s network of suppliers of fresh milk is a fully integrated network of approximately 1,500 dairy farmers in La Laguna and other parts of the country, which has been key to the success of the firm. This network of suppliers has doubled since 1994 and accounts for the largest herd in production (approximately 365,000 cows) with milk yields per cow of between 16 and 24 litres per day. Approximately 23% of these dairy farmers are Lala shareholders and all of them commercialise 100% high quality chilled milk (Hernández Astorga 2005). Within the non-shareholder group, there is a minority with a lower level of technological development which still have problems to reach consistent milk quality (Pérez Duarte Noroña 2005). An estimate of herd sizes indicates that less than 23% of dairy farmers associated with Lala have herds of fewer than 500 cows (García Hernández, Martínez Borrego et al. 2003).

Lala has implemented three strategies to secure the collection of high quality chilled milk (Hernández Astorga 2005):

a) incentive programmes to reward farmers who achieve or exceed their quality parameters and quotas and punish those who do not;

b) technical assistance from a team of 20 agronomists and veterinarians, who provide services to mainly small dairy farmers for herd management (i.e. animal health, reproduction and nutrition) and milk quality control feedback;[190]

c) courses and seminars in La Laguna and other regions to develop best practice in milk production.

Lala's *dairy processing* has followed global trends and the company is a dairy technology leader together with Alpura, Sigma Alimentos and Nestlé. Lala's industrial innovation strategy evolved from a cooperative to a dairy corporation (Rothwell 1996) following a three-phase process (García Hernández, Martínez Borrego et al. 1999; García Hernández, Martínez Borrego et al. 1999) that has affected the region: 1) vertical and horizontal integration to develop a regional agro industry; 2) acquisition of national dairy firms and brands; and 3) global integration favouring the imports of inputs, technologies and services to access export markets. Its strategies include: a) a succession of foreign alliances. For instance, Lala has a joint venture with the Norwegian firm, Elopak, to acquire the franchise of Pure-Pak. Another alliance with the Japanese firm Shikoku is for producing packing material and led to Lala outsourcing to Envases Especializados de La Laguna, a company producing and commercialising food packaging cardboard (García Hernández, Martínez Borrego et al. 1999) and to TetraPak™. It also has an alliance with Candia (a French firm and European leader for aseptic packaging in plastic bottles) (Arista Puigferrat 2005; Arrieta González 2005); b) firms acquisitions: Lala bought the dairy firm Evamex in 2003 with its brands Nutrileche, Mileche, Boreal, Los Volcanes, and Parmalat facility and brand in 2004. This allowed the firm to increase its market share of pasteurised milk in the national market from 40% to approximately 60% in 2005 (Engormix 2004; Hernández Astorga 2005); and c) well integrated network of suppliers of food and dairy technologies (e.g. Danisco, Capacio, Hansen, Rodia, Aristo, etc.) (Otaduy 2005).

The most important innovation products and processes introduced by Lala since 1994 are aseptic packaging in plastic containers; development of yogurts, including pro-biotic products; stabilisation systems for yogurt and fruit drink milk-base, and a milk de-

[190] This includes the services to test milk for fat, protein, cells and bacteria content. The main result is that the firm has established a higher standard for farmers' suppliers than the US for raw fresh milk (Hernández Astorga 2005).

lactosing process. These innovations were developed and assessed by Lala's R&D group (i.e. 12 professionals[191]) in its Gómez Palacio in Durango facility (Hernández Astorga 2005; Otaduy 2005). In 2006, evolution of the intra organisational capabilities of the firm led the production of 42 main groups of dairy products with eight brand leaders, with national distribution and increasing entry to foreign markets (see Table 6.4).

Despite Lala's progressiveness in technology adoption, it is not involved in dairy technology research arguing that the evolution of dairy technologies is very fast-moving making it expensive to catch up with the international technology leaders. However, it has the economic capacity and R&D capabilities to access dairy technology from anywhere in the world and to adapt it to its needs (Hernández Astorga 2005).

In 2005, the main elements of the firm's strategic vision were: a) differentiation in high value products (e.g. natural and healthy dairy products, convenience products and extended shelf life products) to satisfy increasing urban demand; b) large scale of production and distribution (leadership in cost production); and c) expansion of national and international markets in the Mexican south eastern region, the south of the US, Central America and the Caribbean region.[192]

The main organisational change that has occurred in the firm since 2000 is improved management capabilities based on a systematic personnel-training programme combined with a policy of recruiting experienced professionals[193] and development of team work. The main internal mechanisms used by Lala to develop its capabilities include (Chavarría Alarcón 2005): a) training individuals to acquire and use specific knowledge and to change their attitudes to achieve higher performance focused on a holistic approach; b) multidisciplinary group working through the implementation of strategic planning projects; c) developing long-term relationships with milk suppliers

[191] Of this group, 40% have a master's degree in related areas of dairy and food technology (Otaduy 2005).

[192] Lala is aware of the difficulties involved in expanding the Mexican dairy market because of the low income of the population. Therefore, the firm is looking to develop a strong brand position in the Latin American community in the US and Central America. Its expansion strategy focuses on the acquisition and setting up of dairy facilities abroad (Pérez Duarte Noroña 2005).

[193] Lala has recruited professionals from Nestlé and Bimbo (i.e. the largest Mexican bakery and snacks producer) to improve its operations and quality control business processes.

(although Lala does not have a formal contract with milk farmers) through its well developed quality assurance department (Hernández Astorga 2005); and d) reducing hierarchies in the firm to improve communication channels.

Through those mechanisms focused on personnel development, Lala has accumulated some managerial skills and capabilities to support its corporate vision and values,[194] the quick decision-making, the teamwork focusing on solving problems, the well-defined project management capabilities and entrepreneurial capabilities for acquiring and starting up complementary businesses (Hernández Astorga 2005; Otaduy 2005; Pérez Duarte Noroña 2005).

The firm's main achievements can be summarised as follows:

1. becoming the national market leader in liquid milk with consolidation of the milk supply chain (vertical integration of dairy farms) in La Laguna and development in other regions;
2. development of the largest infrastructure for milk and dairy production in the country; some of its facilities got ISO 9002 and 'Clean Industry' certification from PROFEPA; [195] and
3. introduction of new dairy products and processes based on high added value products: pasteurised milk in plastic containers, UHT milk, flavoured milk drinks, set and drinkable yogurt, de-lactosed milk and extended shelf life dairy products.

Tables 5.3 and 5.4 respectively summarise some of the capabilities developed by Lala that support the integration with dairy farmers and dairy production, and describe some of the mechanisms on how they were built from 1994 to 2004.

[194] Sharing values has been a very important factor in the firm's culture development (e.g. hard work, doing things well first time, incremental innovation, trust, collaboration, persistence to achieve aims, ownership of the firm and the region) (Chavarría Alarcón 2005).
[195] PROFEPA is the Mexican Environmental Prevention Agency (i.e. Procuraduria Federal de Protección al Ambiente).

Table 5.3 Lala's capabilities and development mechanisms for dairy farmers' integration

Capabilities	Development mechanisms
Strategic capabilities to become the leader for fresh milk quality[196] Operational capabilities to provide internal services to dairy farmers for animal health, reproduction, and nutrition Operational capabilities to develop manuals for dairy farmers to implement best practice on farms to produce high quality milk Strategic capabilities to develop complementary business (e.g. feedstock production and supply of veterinary products)	Networking with dairy farmers and suppliers of inputs and services Developing joint ventures with veterinary producers Training programmes for dairy farmers in La Laguna and other regions Developing chilling systems including logistics for milk collection and distribution Attending international dairy shows Learning and copying from competitors

Sources: Author's elaboration of information from García Núñez (2005); Hernández Astorga (2005); Pérez Duarte Noroña (2005); Otaduy (2005).

Table 5.4 Lala's capabilities for dairy production and development mechanisms

Capabilities	Development mechanisms
R&D capabilities to develop new products, processes and standards Managerial capabilities to develop internal procedures, operations, and quality assurance Collaborative capabilities to develop joint projects with foreign suppliers of dairy machinery and equipment for processing and packaging and food ingredients to develop new products and processes Strategic capabilities to achieve cost leadership in milk collection and distribution Engineering and operations capabilities to reduce production costs and to develop aseptic packaging systems Information systems development capabilities for operations, logistics and decision making processes Strategic capabilities to start up new business, to acquire firms and dairy facilities, to assess new technologies and partnerships, and to develop new products and markets Strategic marketing capabilities to improve the positioning of the firm (i.e. to increase the market share and to develop a brand strategy)	Technology transfer and training with the suppliers of technology Management training for all the functions in the firm[197] Attending international shows Re-structuring organisation and information systems[198] Developing joint projects with suppliers of services for information systems[199], engineering, quality control processes, development of standards for products and process and testing laboratories pursuing ISO 9002 and HACCP[200] Developing procedures to identify and assess suppliers Acquiring dairy firms Developing chilling and distribution systems including logistics Recruiting professionals from other food production leaders Sponsoring a football team and a marathon to promote Lala's brand

Sources: Author's elaboration of information from Arista Puigferrat (2005); Arrieta González (2005); Chavarría Alarcón (2005); Hernández Astorga (2005); Pérez Duarte Noroña (2005); Otaduy (2005).

[196] This strategy was developed with the dairy farmers to achieve a lower content of somatic cells. High somatic cell content is positively correlated with infections such as mastitis. It achieved a reduction to 250,000 cells/ml vs. the US standards of 350,000 cells/ml (García Nuñez 2005).
[197] For example, the firm has developed a Six Sigma programme with Mancera y Asociados, one of the largest consultancy firms in Mexico for quality processes certification (Chavarría Alarcón 2005).
[198] For example, Lala developed the function of Logistics and Services to serve the new strategy of the firm in the last five years (Chavarría Alarcón 2005).
[199] Lala has a contract with a world-leading supplier of information systems, JD Edwards (Chavarría Alarcón 2005).
[200] Contract with an American firm, to standardise the quality processes and operations of all milk facilities (Arista Puigferrat 2005; Arrieta González 2005).

Lala is actively working to integrate the great diversity of technologies and managerial styles of the different facilities it has recently acquired and to establish joint projects with national and regional universities and research organisations to face international competitors and to expand its market (Arista Puigferrat 2005; Arrieta González 2005).

The second largest dairy processor in the La Laguna and one of the national leaders in the cheese market is *Chilchota Alimentos, SA de CV (Chilchota)*. The firm was set up in 1968 to process 7,000 litres per day and by 2006 had achieved 700,000 litres and produced approximately 1,400,000 tons of cheese and dairy products per year with milk from its own herd of 12,000 cows and a network of 3,500 dairy cow and goat farmers.[201] To ensure a supply of high quality chilled milk, Chilchota provides technical support and financial resources to its suppliers (García Hernández, Martínez Borrego et al. 2003).

In addition to upgrading its cheese technology, Chilchota has diversified into yogurt, fruited milk drinks and cream. It produces some 34 main groups of dairy products under 15 brands in 12 facilities, which include the production of plastic containers, a facility to dehydrate whey, and a large chilling transportation system for the distribution of its products in the national market (i.e. 21 states)[202] (see Table 6.4) and the US. Its strategy relies on systematic training of its employees.[203]

In summary, Lala and Chilchota through their farmers' supporting programmes led improvement in milk production practices, quality of chilled milk and integration of the value chain in La Laguna. These changes amounted to incremental innovation in the main components of the Holstein model (e.g., herd management, agriculture and dairy farming and the organisation to commercialise chill milk) and allowed the firms to improve and develop new dairy products. They improved their standing in the Mexican dairy market and participated increasingly in foreign markets. These improvements also encouraged other dairy firms to collect high quality chilled milk.

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[201] Most of the information on this firm is from Chilchota's web site: http://www.chilchota.com/ (July 20, 2006).

[202] Chilchota is the only one of several large dairy firms that is not in the market for fruit juices but produces milk-based desserts and bakery margarines.

[203] Author's analysis based on information from: Contexto Información Política de la Región Lagunera, Saltillo y Durango Torreón Coahuila Octubre 24, 2004 http://www.sicontexto.com/chilchota.htm (March 15, 2006).

c) Role of the network of suppliers of inputs and services in improving capabilities

The internationalisation of dairy production before GATT and globalisation following GATT and NAFTA have been related to the development of the largest network of suppliers of inputs for agriculture, milk production and dairy processing in La Laguna region (del Valle Rivera 2000). In 1999 there were 84 firms, of which 84% were MNCs (García Hernández, Martínez Borrego et al. 1999). Since the late 1960s and early 1970s, these firms have played a significant role in the modernisation of the dairy region. For instance, DeLaval and WestfaliaSurge suppliers of automatic milking systems increasingly supported the introduction of more automatic milking in farms and thus improved best practice for milking. Therefore, many farmers have increasingly improved the quality of milk, reduced the incidence of mastitis and reduced the demand for non-specialised labour, which is scarce in the region because of the labour demand from the 'maquilas' (Salas Quintanal 2002). Greater use of artificial insemination, sexed semen and embryo implantation promoted by worldwide suppliers (e.g. GEMEX, ABS, Elanco, Bayer, and Pfizer) has improved herd genetics and reproduction cycle management and thus herd productivity (Bredeé Ortíz 2005).

In addition to the MNCs, there is a small group of national firms, which mainly provide services. *Madero Equipos de Ordeño* is one of the main national suppliers of dairy farm management systems to larger dairy farmers (i.e. herds of 600 to 10,000 cows). The firm started in La Laguna in 1989 and from 1993, has had a commercial alliance with SAE Afikim, an Israeli firm, which is a world leader in computerised dairy farm management systems.[204] Since 1996, Madero Equipos de Ordeño has been engaged in technology transfer processes with the participation of dairy farmers, consultants and other suppliers of services, which has contributed to the modernisation of farms in La Laguna and has expanded to other dairy regions in Mexico and abroad.[205]

Madero Equipos de Ordeño offers a variety of services, including farm location, planning, designing (e.g. barns and shading, calving areas, feeding areas, milking parlours, slurry handling facilities, milk cooling and storage), supervising facilities

[204] SAE Afikim is a MNC with branches in Australia, China, the Czech Republic, Ireland, Italy, South Africa, Spain, the UK and Venezuela. See http://www.afikim.co.il (March 30, 2006).

[205] Madero Equipos de Ordeño has branches in Delicias (Chihuahua), Querétaro (Querétaro) and Aguascalientes (Aguascalientes), and in the US in Cabo Rojo (Puerto Rico) and has implemented systems in Venezuela (Madero Gámez 2005).

construction, and computerised management systems, which collectively amount to offering a turnkey design for dairy operations. It has a team of 10 professionals in engineering and design of milk production systems and 50 engineers and technicians specialised in the implementation of milk and dairy management systems. Its main contribution in the region is the development of technological capabilities for farm management based on the firm's experience[206] (Madero Gámez 2005) (see Table 5.5).

Table 5.5 Madero Equipos de Ordeño capabilities and development mechanisms

Capabilities	Development mechanisms
Developing dairy farm systems adapted to regional conditions including herd management, animal nutrition, manure management and water recycling for irrigation in forage production Strategic capabilities to become a national and international firm	Technology evaluation and acquisition from foreign suppliers Attending conferences with suppliers of herd management systems, animal health, nutrition and reproduction On-farm training courses for herd management, project management, and assessment of farm information systems Farmers' data recording to improve herd management systems Developing specialised software systems

Source: Author's elaboration of information from Madero Gámez (2005).

This highly developed infrastructure of suppliers in La Laguna, which is not present in the other dairy regions, has also supported a leadership position for poultry and egg production in La Laguna (Aguilar Valdés 2005; García Hernández, Aguilar Valdés et al. 2005; Madero Gámez 2005).

The efforts of the suppliers of services and inputs for milk production demonstrate that this group of firms has been very supportive of the capabilities development of the region. The setting up of Madero Equipos de Ordeño in 1989 might be an indication that opportunities increased for local firms to enter into the business. However, a high dependence on foreign inputs for agriculture and dairy production makes La Laguna highly sensitive to economic fluctuations (Salas Quintanal 2002). Furthermore, it has been questioned why the region has not been able to develop local suppliers of inputs (e.g. supply of heifers, semen, grains, milking systems, etc.) to decrease this dependence, which threatens the competitiveness of the region (Aguilar Valdés 2005;

[206] Pedro Madero Gámez, the firm's owner has personal experience as a dairy producer with a herd of 220 cows, which he reports as having achieved high yields (i.e. 30 to 35 litres per day per cow).

García Hernández, Aguilar Valdés et al. 2005; Luévano González 2005; Luna Prieto 2005).

d) Role of the network of financial suppliers in improving capabilities

In addition to the commercial banks, which have a strong presence in the region (e.g. BANORTE)[207], UCIALSA[208] (which is a regional credit union of dairy farmers and part of the Grupo Industrial Lala, operating with resources from FIRA) provides resources mainly for the development of milk production infrastructure and the supply of forage (approximately 90% of regional consumption) (García Hernández, Aguilar Valdés et al. 2005, p 151).

The role of public organisations for development has also been important in the development of the dairy region. For example, *FIRA* has provided the resources for development of the dairy infrastructure since at least 1972 (e.g. acquisition of specialised dairy cow breeds, start-up of pasteurisation facilities, development of technology alliances of Lala with Elopak, and support for Lala's acquisition of dairy firms)[209] and continues to do so. For instance, in 2004 it allocated 50% of its budget to milk production compared to 30% to poultry, and 20% to greenhouse and cotton crops (Luna Prieto 2005).

FIRCO and Financiera Rural have financed the acquisition of inputs to improve forage production and irrigation infrastructure (Martínez Borrego, Salas Quintanal et al. 2003, p 182; Luna Prieto 2005). However, the amount of resources available for these efforts has been insufficient to support small farmers' efforts to build up their infrastructure and develop their capabilities (Aguilar Valdés 2005; Luévano González 2005; Luna López 2005; Salas Quintanal 2005). The main impact of these efforts has been for big

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[207] BANORTE is a commercial bank owned by Roberto González, the owner of MASECA, the largest tortilla producer in Mexico, one of most important agribusinesses in the country.

[208] UCIALSA owns 58% of its resources and 42% come from FIRA (Fitch Rating: http://www.fitchmexico.com/espanol/Listados/Financieras/Archivos/UCIALSA.pdf (March 30, 2006). UCIALSA has demonstrated high growth and good performance according to FitchRatings due to the quality of its human resources and management team, its technological assets, and the growth of Grupo Industrial Lala. FitchRatings websites: http://www.fitchmexico.com/Noticias/NW_156.pdf and http://www.fitchmexico.com/espanol/Listados/Sofoles/Archivos/UCIALSA.pdf. (March 30, 2006).

[209] FIRA in 1972 established a technology transfer centre, Centro Demostrativo Ignacio Zaragoza in Gómez Palacio, Durango. For 15 years, it supported the training of farmers in the use of artificial insemination to improve herd genetics, animal nutrition and heifer development (García Hernández, Aguilar Valdés et al. 2005, p 166).

dairy farmers, especially those benefiting through UCIALSA, many of whom may also be shareholders of Lala.

e) Role of the universities and regional research centres in improving capabilities

University interactions with farmers and dairy processors are limited in La Laguna region. At the time of the fieldwork, the region had a network of some 11 universities and colleges with programmes in agriculture, veterinary science, business and management.[210] However, it seems that their programmes are not upgraded and they do not engage in research programmes to address the regional needs of dairy producers (e.g. masters programmes in agribusiness and dairy technologies), which need a multidisciplinary body of knowledge, and skills for agribusiness and regional sustainability (Aguilar Valdés, García Hernández et al. 2000; Aguilar Valdés and Rodríguez Bazaldua 2004; Aguilar Valdés 2005). One exception is *UAAAN* [211] (see Appendix I, section 1.2), which in the period from the early 1990s to 2005 developed extensive research into the economics of the dairy region in cooperation with other regional organisations such as the UGR La Laguna and Lala (Aguilar Valdés 2005; Luévano González 2005) (see Table S5.3); and *ITESM, Campus La Laguna*[212].

ITESM Campus La Laguna was set up in 1975 and since then it has influenced the education of regional populations through its agribusiness-oriented teaching university and training programmes, which attempt to establish a process of continuous quality improvement on farms, and innovation along the supply chain[213] (Aguilar Valdés 2005;

[210] They are: Universidad Autónoma Agraria Antonio Narro, UAAAN; Escuela de Agronomía de Venecia, Facultad de Agronomía y Zootécnia, Universidad Juárez de Durango; Instituto Agropecuario No. 20; Universidad Autónoma de Chapingo Unidad La Laguna, Zonas Aridas in Bermejillo; ITESM La Laguna campus; Universidad Anáhuac; Universidad Iberoamericana, La Laguna campus; IPN Unidad SEAD; Universidad Autónoma de La Laguna; Universidad del Valle de México; and Centros de Bachillerato Agropecuario (CBTA) (García Hernández, Aguilar Valdés et al. 2005).

[211] UAAAN has two campuses located in the La Laguna region, Buenavista and Saltillo in Coahuila. It specialises in agriculture and undergraduate and postgraduate training in agriculture, animal husbandry and agro economics subjects.

[212] The ITESM Campus la Laguna is part of the ITESM, Instituto Tecnológico y de Estudios Superiores de Monterrey system, which is the largest and most prestigious private university system in Mexico. It was set up in Monterrey (Nuevo León state) in the early 1950s to provide technical and managerial skills for industry in the north of Mexico. It has expanded to a nationwide network of about 34 campuses and a network of alliances with other universities in Latin America and the USA to deliver mainly MBA courses.

[213] Similar training programmes have been developed by ITESM Campus La Laguna for other agribusinesses in the region e.g. Hortalizas La Laguna (a firm in the Soriana Group, the largest retailer in the region), Bachoco and Tyson (two of the largest egg and poultry producers in Mexico) (Becerra Huerta 2005; Facio Lícera 2005).

García Hernández, Aguilar Valdés et al. 2005; Nuñez Hernández 2005; Pérez Duarte Noroña 2005). These programmes attract people from many parts of the country. The training programmes are designed to develop management skills and operational capabilities for farmers, dairy processors and government officials from SAGARPA, INIFAP and Financiera Rural for rural development (see Table S5.2) (Becerra Huerta 2005; Facio Lícera 2005). Several other organisations, e.g. Colegio de Veterinarios de La Laguna, INIFAP Matamoros and consultancy firms, have been very successful in delivering training courses for agriculture and milk production in the region since the middle of the 1990s (Aguilar Valdés 2005; Nuñez Hernández 2005).

In addition to education and training programmes, since 1993 ITESM Campus La Laguna has been involved in the organisation of a large annual forum for updating technologies for specialised milk production systems, i.e. ENGALEC[214] (i.e. Encuentro Nacional de Ganaderos Lecheros, National Forum of Dairy Farmers). ENGALEC aims at the development of dairy farms to achieve socio-economic sustainability. ENGALEC[215] bring specialists in herd management, optimisation of water use for alfalfa production, farm design, slurry management, etc. Other dairy regions have emulated it and run similar events, e.g. DIGAL[216] in Chihuahua state and CIGAL[217] in Jalisco state. However, there are some political, economic and cultural barriers to dairy farmers' participation in the training programmes[218] (Bredeé Ortíz 2005).

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[214] ENGALEC is a technical and social event that brings together farmers, suppliers and specialists in milk production. It has a committee that includes the agronomy alumni of ITESM (i.e. IATEM), the dairy farmers association (i.e. Asociación Nacional de Ganaderos Lecheros A.C., ANGLAC), the livestock producers' association of La Laguna and Gómez Palacio, Durango (i.e. Unión Ganadera Regional de la Laguna y de Gómez Palacio, Durango), ITESM, La Laguna and the Holstein association of Mexico. Federal and Coahuila and Durango state governments, Lala, Alpura and Nestlé fund the forum (Bredeé Ortíz 2005). It is believed that ENGALEC and ANGLAC represent the vested interests of the large dairy farms that 'manipulate' and block developing policies for small dairy farmers and dairy producers (anonymous interviewees).

[215] See the ENGALEC website for forum programmes: http://www.lag.itesm.mx/engalec/ (September 30, 2005).

[216] DIGAL is Día Internacional del Ganadero Lechero (International Day for Dairy Farmers) which has taken place in Delicias, Chihuahua since 1998, and is similar to CIGAL.

[217] *Grupo CIGAL, S.A. de C.V.* is a private firm that hosts an annual international conference (since 1984) and commercial exhibition for dairy cattle (Conferencia International sobre Ganado Lechero, CIGAL), organised by suppliers of inputs for dairy cattle and Holstein Mexico. Holstein, a private organisation was set up in 1962 to register the genetics of the specialised milk cows, the Holstein breed (Cevallos Urueta 2005; Ruíz López 2005).

[218] Examples include: a) syndromes of very busy business people focused on short-term benefits, and 'I know everything about my business, therefore, I do not need further training'; b) lack of interest among farmers in training their workers, e.g. farm managers, 'mayordomos', professionals and non-specialised labour, and c) high mobility of the professionals due to lack of incentives to remain in the regions, e.g. low salaries and lack of training (Bredeé Ortíz 2005).

Additionally, despite the importance of milk and dairy production in the region, in rural areas there is a lack of updating of agriculture development programmes by the institute for rural development, Instituto Nacional de Capacitación Rural, INCA Rural from SAGARPA (Rodríguez Garza 2005); which affects mainly small farmers and the labour market for milk production.

In terms of agriculture research, *INIFAP Matamoros,* which is part of the research network of INIFAP in Chihuahua, Aguascalientes and Querétaro for specialised milk production systems, has developed since the middle 1980s a research programme for feedstock production. This involved INIFAP researchers and dairy farmers with resources from the Federal programme (i.e. Comité de Fomento Agropecuario) (Nuñez Hernández 2005; Ruíz López 2005) and Fundación Produce La Laguna developed the PIAL projects to identify dairy farmers' needs for milk production. PIAL joint research focused on integrated development of forage technologies for the production of alfalfa and other grains addressing the economic sustainability of the dairy production in the region.[219] It has its own project management structure and research protocols based on multidisciplinary research teams including farmers' participation (e.g. monitoring the forage productivity on farms, the herds' nutrition programmes and the milk cows' productivity) (García Nuñez 2005; Nuñez Hernández 2005). However, overexploitation of the region's water has not been fully addressed in a research programme. This constitutes one of the main threats to the economic development of the region and, together with the pollution of water effluents and production of gas methane threatens further the competitiveness of the region (Hernández Laos and del Valle Rivera 2000; Aguilar Valdés 2005; Lomelí Monreal 2005).

f) Role of the organisations for regional development

The new development organisations post-NAFTA include the *Fundación Produce La Laguna*, which is a unique regional development organisation for agriculture.[220] It was

[219] Research areas include: a) irrigation methods to improve water use and disease control in alfalfa; b) ruminant digestion of fibre and protein; c) production of grains for forage (i.e. Balboa maize, sorghum and oats) to improve nutrient content in milk; d) bio-fertiliser production from manure using worms; e) integrated methods to prevent plant disease due to drought; and f) re-utilisation of water from sheds for irrigation on farms (Núñez Hernández 2005).

[220] This is an unusual regional organization. The other states in the country have State offices, e.g. Fundación Produce Jalisco, FUNPROJAL (see Los Altos case) and Fundación Produce Tabasco (see Tabasco case).

set up in 1995, as part of the Federal programme Alianza para el Campo (see Appendix I, section 1.2). It has resources from Fundación Produce of the state of Durango (33%), Fundación Produce of the state of Coahuila (42%) and La Laguna farmers (25%) to carry out regional research with INIFAP Matamoros. It has a board of trustees for agriculture and dairy livestock research in La Laguna, PIAL, which assesses project proposals, selects them and allocates resources accordingly (Iruzubieta Quezada 2005; Nuñez Hernández 2005). A demonstration of PIAL's projects has been held annually since 2001 with 'field day demonstrations'[221] and participation from agricultural suppliers. SAGARPA La Laguna, and UGR La Laguna distribute technical reports and electronic information to regional farmers. This event is one of the most important regional technology transfer mechanisms, which includes the codification of indigenous knowledge in reports and videos. Some of PIAL's most successful projects are in the areas of forage production and animal nutrition and to a lesser extent in water recycling and slurry management on farms, for instance, a reduction in the ratio of maize to alfalfa from 1:4 to 1:1.5 for animal nutrition in the period 1995 to 2005 (García Nuñez 2005; Iruzubieta Quezada 2005; Nuñez Hernández 2005)[222]; and the production of bio fertiliser from manure using worm cultures (Martínez and Ramírez 2000). However, these projects have been less successful than the forage production projects because of the limited participation of farmers (Aguilar Valdés 2005) and limited resources to implement the research projects[223] (Iruzubieta Quezada 2005; Nuñez Hernández 2005).

Another important actor in regional development is the *Unión Ganadera Regional de La Laguna (UGR La Laguna)*, which is the largest dairy cattlemen's organisation in La Laguna. It incorporates six local associations and has an important representation from dairy farmer stakeholders of Lala.[224] UGR La Laguna lobbies the Federal and state governments for resources from Alianza para el Campo, FIRA, FIRCO and Financiera Rural and has helped in the diffusion of PIAL projects – development of services to import pure breed cows and studs, development of programmes for animal health and

[221] It is a technical demonstration of project achievements on a specific farm.

[222] The production of alfalfa consumes very high volumes of water/ha compared to other crops (approximately 27.4 cum/ha for alfalfa vs. 2.2 cum/ha for maize) (Martínez Borrego, Salas Quintanal et al. 2003, p 98).

[223] PIAL supplies 50 to 80% of the budget for its projects but this excludes the wages of INIFAP researchers (Nuñez Hernández 2005). In 2005, the budget was Pesos 5m, which was considered very low for the research needs of the region (Iruzubieta Quezada 2005; Núñez Hernández 2005).

[224] The UGR La Laguna has approximately 350 members, 90% of whom are suppliers of Lala and own more than half the milking herd in the region (Lomelí Monreal 2005).

production of safe food (i.e. SENASICA)[225] (Aguilar Valdés 2005; Lomelí Monreal 2005) – and the development of a joint project with SAGARPA and UAAAN to build an updated animal test laboratory for tuberculosis and brucellosis eradication (Delgado 2005).

In terms of supporting government organisations, *SAGARPA La Laguna* (which is also a unique government regional office similar to Fundación Produce La Laguna), was set up by decree of La Laguna in 1977. It implements the national agriculture and livestock sectoral policies of SAGARPA (i.e. Plan Sectorial Agrícola Ganadero) through the supply of resources from Alianza para el Campo to improve the infrastructure for milk production (e.g. irrigation systems, mechanisation of the agriculture, eradication of tuberculosis and brucellosis, and imports of heifers to avoid BSE cross-contamination), and rural development programmes.[226] It is also engaged in updating information about regional agriculture production, irrigation land, crop prices, etc. in coordination with SAGARPA Federal office and the Secretary of Economy, to facilitate the planning and decision-making of the actors in the region. Nevertheless, there is a lack of accurate information on the costs of production and farm productivity (Rodríguez Garza 2005).

The evolution of the La Laguna dairy region is considered a social and economic phenomenon and has been the subject of much research by UNAM, UACh, UAAAN and SOMEXAA,[227] resulting in extensive publications in papers and books, some of which are drawn on in this thesis research. UGR La Laguna has undertaken numerous efforts to record the success of the La Laguna dairy region, from 1993 to 2000, including an annual publication produced by ENGALEC members and the Lala executive board (see some examples in Table S5.3). However, there are no formal institutions to further develop the region on sustainable bases (e.g. safety in water

[225] SENASICA is Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria responsible for national services for health, safety and quality in the agro food industry. SENASICA is a decentralised organisation of SAGARPA in charge of activities to protect agriculture, fisheries and livestock from disease, reduce the risk of food contamination and increase the quality of food to promote national and international trade.
[226] There are rural training programmes provided by SAGARPA through the National Institute for Rural Training (i.e. Instituto Nacional de Capacitación Rural, INCA Rural). However, they have not been assessed and have had low impact on users (Rodríguez Garza 2005).
[227] SOMEXAA is the largest Mexican association of universities and research organisations (Sociedad Mexicana de Administración Agropecuaria, A.C.), set up in 1984 to diffuse Mexican agribusiness research through the journal 'Revista Mexicana de Agronegocios' (Aguilar Valdés 2005).

supply, slurry management, standards for farms, etc.) (Aguilar Valdés 2005; García Hernández, Aguilar Valdés et al. 2005; Luévano González 2005; Luna Prieto 2005).

In summary, this section has discussed the structure of the La Laguna dairy system, its main features and the efforts of actors that have led to it outperforming all other dairy regions in Mexico. The next section discusses the main achievements of the La Laguna dairy system and assesses the roles of the actors whose collaboration has supported the expansion of the region based on the evidence provided in this subsection.

5.1.3 Functions and dysfunctions in La Laguna dairy system: assessing the roles of the actors involved in capabilities building

As noted earlier, the structure of La Laguna dairy region is straightforward; it comprises a small number of farmers with large herds of specialised milking cows, which produce on average high yields of high quality chilled milk, and two main dairy processors: Lala, one of the leading dairy producers in the national market, which integrates most of the large and medium-sized farmers of the region; and Chilchota, the second largest dairy processor in the region, which perhaps integrates many of the remaining farmers in the region. Other regional actors have supported technology transfer and learning mechanisms, which have assisted farmers to change their existing routines into improved capabilities for milk production. The main mechanisms for capabilities development can be summarised as follows:

a) Lala and Chilchota employing a group of veterinarians, provided assistance to dairy farmers for animal health, reproduction and nutrition and tested the quality of chilled milk to secure their supply of high quality chilled milk;
b) PIAL project (i.e. the joint efforts of INIFAP Matamoros, Fundación Produce La Laguna and farmers) developed appropriated indigenous technologies for forage production to improve milk production yields and to reduce costs;
c) ITESM Campus La Laguna, ENGALEC and suppliers of inputs for milk production provided training programmes to improve the knowledge and skills of farmers to improve the technological components of the intensive milk production systems;

d) Other organisations (i.e. Madero Equipos de Ordeño, UGR La Laguna, SAGARPA La Laguna, UAAAN, SOMEXAA) increasingly codified indigenous/local technologies (i.e. farm information systems and milk quality registers), developed research and published in magazines and books; and

e) Dairy farmers and dairy firms increasingly adopted and used software and information systems to improve herd management, logistics and other operations adapted by Madero Equipos de Ordeño.

As a consequence, La Laguna region has developed and accumulated the following capabilities in the area of milk production and commercialisation (see Table 5.6).

Table 5.6 The La Laguna dairy system capabilities development for milk production and commercialisation

Technological capabilities	Organisational capabilities
Adapting worldwide technologies to improve animal health, reproduction and nutrition, intensive use of milking and chilling systems, and best practice on farms Design capabilities to build up farms (e.g. sheds designed for animal comfort and control systems, manure management, water treatment and re-utilisation, etc.) Developing regional technologies to increase productivity in agriculture and animal nutrition (e.g. technologies for alfalfa, sorghum and maize and silage production for animal nutrition, assessment of the digestibility of the feedstock) Developing and implementing best practices to produce and preserve high quality milk Research capabilities of INIFAP Matamoros for forage production and economic sustainability of milk production with UAAAN	Developing networks of suppliers of high quality chilled milk Developing and implementing training programmes for agriculture and herd management Developing joint research projects for animal health, reproduction and nutrition Developing herd management capabilities (i.e. animal nutrition, reproduction and health) using information systems Strategic capabilities to achieve national leadership for fresh milk and dairy production Developing services to dairy farmers for animal health, reproduction, and nutrition Relational capabilities to attract resources (i.e. lobbying) from Federal and state governments for research to attend to regional needs (i.e. PIAL) and to build infrastructure (i.e. UCIALSA)

Source: Author's elaboration.

In the case of milk industrialisation, the mechanisms for collaborative learning processes employed to create the capabilities for dairy processing include: a) Lala R&D group developed dairy technologies in alliances with international firms;[228] b) Lala received technical assistance from national and international consultants on quality assurance, to standardise Lala's dairy facilities practices; and c) Lala management provided training programmes to help the firm's individuals create the knowledge to improve the capabilities of the firm.

[228] It could have also been possible that Chilchota had alliances with foreign and national suppliers for dairy production. However, it was not possible to get primary information from the firm.

The main capabilities developed in the region for dairy industrialisation are summarised in Table 5.7.

Table 5.7 The La Laguna dairy system capabilities development for dairy industrialisation

Technological capabilities	Organisational capabilities
Adapting dairy technologies from foreign suppliers of dairy machinery and equipment, packaging and food ingredients to develop new dairy products, processes, aseptic packaging, and processes standards Operational capabilities to development information and logistics systems to improve the decision-making processes for dairy production	Strategic capabilities to assess new technologies and partnerships for new dairy products and market development Managerial capabilities for R&D, operations, marketing and quality assurance for products, processes and standards Strategic capabilities for acquisition of firms, and start up new businesses Strategic capabilities to achieve cost leadership for milk collection and distribution Strategic capabilities to develop complementary businesses (e.g. feedstock production, supply of veterinary products and financial services) (i.e. the formation of Grupo Industrial Lala)

Sources: Author's elaboration.

As can be noted in Table 5.2, the improvement in milk production capabilities in La Laguna contributed to the outstanding economic results of the region in the period of analysis (1994-2004), which show that La Laguna significantly increased its share of national milk production (i.e. 20.00% in 1994 compared to 23.64% in 2004). The growth in milk production was higher than the national one (5.83% vs. 3.04%), as well as the dairy cattle growth (i.e. 4.94% vs. 3.20%). The region has also outperformed Tabasco and Los Altos regions (see Table 6.1).

Some of the achievements of the La Laguna dairy system are listed below.

1. A wide and homogeneous application of the intensive model for milk production.
2. A well-developed network of dairy farmers producing high quality chilled milk.
3. A well-developed network of regional suppliers of inputs for agriculture, milk and dairy production.
4. An improvement in the professional profiles of dairy farmers.
5. Increased codification and systematisation of endogenous knowledge from farms.
6. Expansion of Lala, Chilchota and Madero Equipos de Ordeño.
7. Development of new milk and dairy products, processes and specifications, including packaging materials by Lala and Chilchota.

Blocking mechanisms and constraints for capabilities building

In La Laguna, dairy farmers and firms supported by regional development organisations have developed capabilities to succeed in the production of milk and dairy products. However, these achievements have also been accompanied by some constraints and problems. By far the most important one is related to the supply of water for feedstock and milk production. It is in the interest of both dairy farmers and their forage suppliers to increase the production of milk, which necessitates increasing levels of water consumption. This problem of water supply has been under discussion for many years (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000) with no consensus on its long-term sustainability. On the other hand, there are also the interests of the region's citizens to consider. They claim that domestic water supplies are being affected because of the over-exploitation of water by dairy farming,[229] and the contamination of well water, frequently due to increased slurry production. All of these issues need to be considered in assessing the long-term sustainability of the region (Aguilar Valdés 2005; Iruzubieta Rosales 2005; Lomelí Monreal 2005).

An additional potential constraint on the profitability of milk production is the heavy dependence on foreign suppliers, which is not considered by the dairy farmers as a risk factor (Aguilar Valdés 2005; Luévano González 2005). For instance, when BSE was found in US and Canadian herds (1996-2003)[230], Mexican farmers were not able to import heifers from those countries, the main suppliers of specialised heifers, because of sanitary restrictions by SAGARPA. La Laguna dairy farmers bought heifers from Jalisco farmers and it was argued that this might have an effect in the long term of milk production in Jalisco (Pérez Burgos 2005).

Table 5.8 summarises the evidence from the analysis of collective activities of different actors that contributed to capabilities development supporting functions as well as the blocking mechanisms and constraints that have impeded the development of capabilities and led to dysfunctions.

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[229] It is estimated that each cow accounts for some 350 litres of water per day, which includes actual consumption and water for cleaning (Martínez Borrego, Salas Quintanal et al. 2003, p 98).

[230] Trade in heifers was re-established with the US at the end of 2006. http://www.usda.gov/wps/portal/!ut/p/_s.7_0_A/7_0_1OB?contentidonly=true&contentid=2006/10/0397.xml (June 28, 2007).

Table 5.8 La Laguna dairy system's functions and dysfunctions

Functions	Dysfunctions
Creating and diffusing knowledge	
Diffusing updated milk production technologies and managerial skills in farms (national and international suppliers of inputs for milk, ITESM La Laguna training programmes, Madero Equipos de Ordeño, PIAL projects, INIFAP Matamoros and ENGALEC) Diffusion of regional dairy activities (regional publications from Lala, UAAAN, UGR La Laguna and SOMEXAA) R&D capabilities to improve milk production and to develop new dairy products (Lala and Chilchota and international suppliers)	Insufficient training to improve human capabilities in small farms (e.g. herd management, intensive grazing practices, hygiene practices, etc.)
Driving research process	
Creating PIAL to influence research for regional milk production (INIFAP Matamoros and Fundación Produce La Laguna and dairy farmers) Developing joint research of La Laguna dairy system (Lala, UGR La Laguna, UAAAN and SOMEXAA)	Lack of research and institutions to develop the vision and economic bases for the environmental sustainability of the dairy system (e.g. water supply, slurry management and social problems created by dislocation of farmers)
Entrepreneurial experimentation	
Developing suppliers to design and operate dairy farms (Madero Equipos de Ordeño and foreign suppliers) Firms' innovative activities to expand production capacities by acquisitions (Lala) and building new facilities (Chilchota)	Lack of networks to develop regional domestic suppliers of inputs for agriculture and milk production to decrease the risk of increasing production costs due to high dependence on foreign sources
Facilitating the formation of the markets	
Expanding national and international markets of milk and dairy products (Lala, Chilchota and Madero Equipos de Ordeño) Creating a national network of suppliers of high quality chilled milk (dairy farmers and Lala, Chilchota, Alpura and Nestlé)	Lack of institutions to create a labour market (professionals and non-specialised labour) for milk production due to low salaries and poor incentives, which encourage mobility to other dairy regions
Developing positive externalities	
Developing institutions for animal disease control (dairy farmers, SAGARPA La Laguna, UGR La Laguna) Creating a network of suppliers for agriculture and milk production (suppliers of inputs, and ENGALEC) Attracting dairy processors to collect milk (Alpura and Nestlé) Creating alliances with other firms (e.g. Lala)	Displacing small dairy farmers and creation of social problems Creating problems in water supply and water contamination Lack of institutions to upgrade university education and research programmes on agribusiness development (e.g. masters programmes in dairy technologies, animal production, capacities certification, etc.)
Legitimation	
Legitimation of the intensive Holstein model (dairy farmers, Lala and government organisations) Creating a culture of high quality chilled milk (dairy farmers and dairy firms)	Lack of effective institutions and industrial standards for dairy farms for water supply, slurry management and air pollution
Mobilising resources	
Providing public and private investment for the modernisation of the system (Alianza para el Campo, dairy farmers, FIRA, Financiera Rural, UCIALSA, Lala and Chilchota)	Lack of available lending resources to deal with modernisation of small dairy farms

Source: Author's elaboration.

5.2 Temperate regions and the semi-intensive and intensive milk production systems: the case of Los Altos dairy region in Jalisco state

Jalisco has been an important centre for livestock and agriculture since colonial times, when it served the neighbouring mining states of Zacatecas and Guanajuato. At that time, beef production was the most important economic activity with milk a side business, which was commercialised regionally as non-chilled milk and artisan dairy products (e.g. cream, regional cheeses and milk-based confectionery). Livestock production was (and still is) characterised by small and medium-sized private farms, which were unable to expand into intensive beef systems, due to lack of large grazing areas, a consequence of the Mexican Revolution and implementation of the land reform of the Cardenista period (1935-1940), which abolished latifundios and promoted the formation of 'ejidos' and communal land holding. Farmers went into milk production using dual-purpose systems (del Valle Rivera, Hernández Tinajero et al. 1999), which have been evolved steadily into semi-specialised and (very few) specialised systems (Cervantes Escoto, Santoyo Cortés et al. 2001).

In terms of dairy operations, it was not until Nestlé (a Swiss firm) was established in 1935 in Ocotlán, and Carnation (an American firm) was established in 1944 in Lagos de Moreno (one of the most important milk production municipalities of the Los Altos region) that milk industrialisation started and Los Altos region became a 'dairy basin' (del Valle Rivera, Hernández Tinajero et al. 1999). Since then, the increased production of milk in Los Altos and in the whole state of Jalisco has attracted investors to set up dairy processing in Guadalajara (i.e. Lechera Guadalajara, in 1961), and in Lagos de Moreno – Alimentos La Concordia in 1994, Sigma Alimentos in 1995 (from Monterrey), and the Italian firm Parmalat in 1996 (now part of Lala).

Jalisco is the largest state producer of milk and second after La Laguna region. Los Altos is the most important milk-producing region (approximately 62% of total of milk production in 2002) in the state of Jalisco. Farmers in Los Altos (and Jalisco) mainly operate family-run production systems (70-80% using family labour), and increasingly semi-intensive and intensive systems (20-30% hiring specialised labour). It is estimated that around 38% of farms have introduced some features of the intensive systems and use grazing and supplementary grains produced in the region (Cervantes Escoto, Santoyo Cortés et al. 2001). Therefore, Los Altos dairy region has heterogeneous technological levels and varying milk qualities depending on which firms dairy farmers are associated with (Cervantes Escoto 2005; Falcón Estrada 2005; Soltero Gardea 2005).

The Los Altos dairy system experimented with important changes which have led to the expansion and diversification of the markets since the mid-1980s when Nestlé and Lechera Guadalajara pressured farmers to improve milk quality for industrialisation (Anaya Zermeño 2005; Chombo Morales 2005; Ortíz 2005; Téllez Abaunza 2005; Quintanilla Alvarez 2006). Nevertheless, the introduction of technology, the improvement in dairy farming and the scale of milk production required to be competitive remain a concern for dairy farmers and dairy producers and other government agencies (Cervantes Escoto 2005; Falcón Estrada 2005; Soltero Gardea 2005).

5.2.1 Los Altos transformation from family farms to semi-intensive and intensive milk production systems and NAFTA

The transformation of Los Altos to intensive milk production is a long process that is still not complete and which implies that NAFTA was not ‘the trigger’ for major change in this region (Cervantes Escoto 2005; Soltero Gardea 2005). However, GATT and NAFTA do appear to have affected the system in various ways (Rodríguez Gómez 1998a; Rodríguez Gómez 1998b; Cervantes Escoto and Alvarez Macías 2001; Cervantes Escoto, Santoyo Cortés et al. 2001; Cervantes Escoto 2003).

The Los Altos region has been beset by problems related to a lack of strategies to stabilise the market price for fresh milk, which has had a negative impact on dairy farmers’ incomes. During the high season for milk production (June to October), there is a surplus, which leads to a decrease in the price of fresh milk. It is also during this period when schools are closed for the holidays, which further reduces demand and worsens the positions of the many small dairy farmers (Soltero Gardea 2005). These fluctuations in price reduce profits and discourage investment. In addition, traditionally, farmers have sold non-chilled milk, which is sometimes of poor quality due to poor hygiene practices on some farms and the lack of chilling systems. A major share of milk is sold through ‘ruteros’, many of which do not have chilled transport. Furthermore, 'ruteros' adulterate the milk with the addition of water to increase the volume or with chemicals to delay the bacteriological process and decomposition of the milk during transport to the dairy processors (Chombo Morales 1998).

NAFTA increased the pressure on dairy processors and in turn on dairy farmers to produce better quality milk to counter the growing imports of NFDM and dairy products. For Jalisco dairy companies, it was cheaper to re-hydrate imported NFDM to produce dairy products. This appears to have decreased demand for fresh milk and led to the displacement of a number of dairy farmers in the Los Altos region[231] (Rodríguez Gómez 1998a; Cervantes Escoto 2003; Cervantes Escoto 2005; Chombo Morales 2005; Rodríguez Gómez 2005). Nevertheless, many farmers introduced agricultural and milk production technologies and NAFTA may have worked to improve access to inputs for the modernisation of the industry, as has been suggested for other regions (Callieri 2005; Caraveo Márquez 2005; Hernández Astorga 2005).

This modernisation might have been funded (at least in part) by remittances from Jalisco migrants living in the US,[232] and possibly allowed dairy farmers to survive pressure from NAFTA and the dairy processors. Traditionally, dairy farmers have preferred to buy a cow or a tractor as means of saving from income (Rodríguez Gómez 1998b; Rodríguez Gómez 2000; Cervantes Escoto, Santoyo Cortés et al. 2001; Falcón Estrada 2005), which might explain, in part, the on-going transformation of the regions.

5.2.2 Structure of the Los Altos dairy system and actors' role in the evolution of capabilities

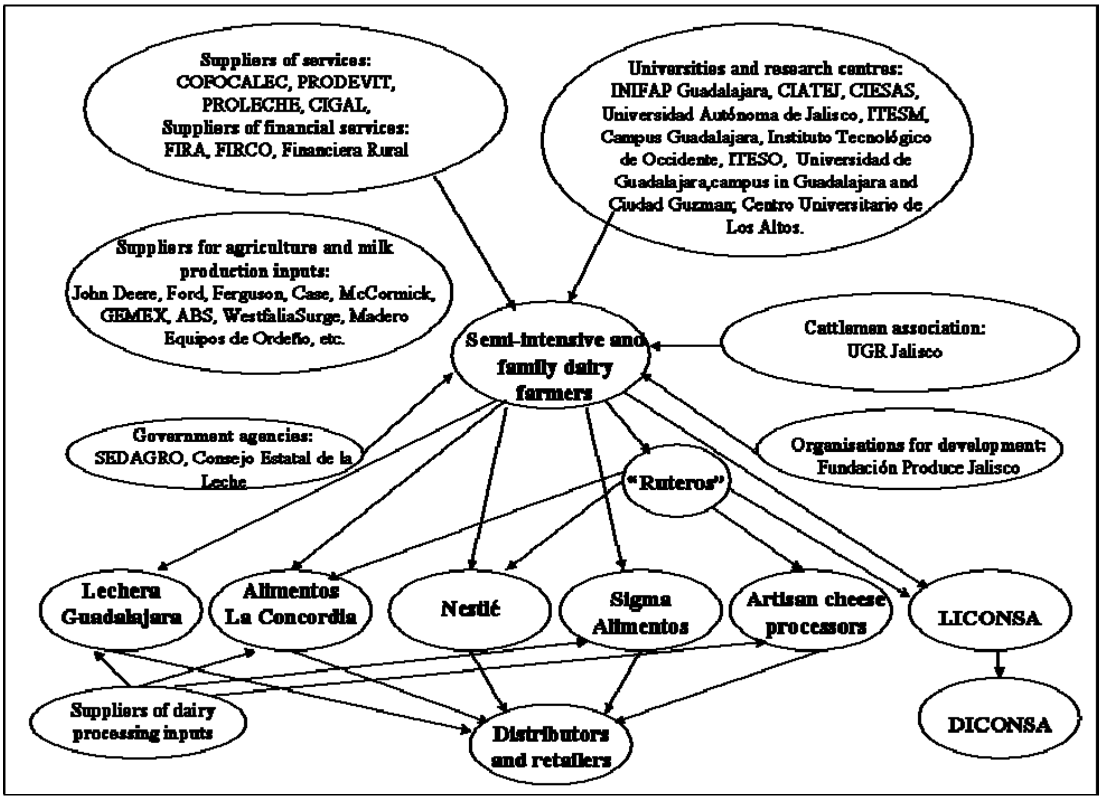
Large dairy processors, Nestlé and Lechera Guadalajara, demanded and imposed standards for chilled milk on dairy farmers who had already initiated the adjustments required for the Los Altos region to deal with the challenges of NAFTA. These

[231] It is estimated that 25-40% of farmers in the region left farming between 1995 and 2002 (Cervantes Escoto 2003). However, there is no clear evidence or data on why this happened. For example, del Valle Rivera, Hernández Tinajero et al. (1999), p 214-215 state that there were approximately 15,000 dairy farmers in 1995. At the time of the fieldwork in 2005, the number of dairy farmers was estimated at 16,000 (Arellano Leaño 2005; Valencia Zarazúa 2005).

[232] Jalisco together with the states of Michoacán, Zacatecas and Guanajuato, is one of the largest suppliers of agricultural labour to the US (Rodríguez Gómez 2005).

adjustments restructured the value chain, which involved many actors and led to a regional dairy system of greater complexity than that in the La Laguna region.

The Los Altos dairy system of innovation referred to here is a set of some specialised and semi-specialised, but mostly family dairy farms, with increasingly integrated networks to supply better-quality chilled milk to several dairy firms. As in the case of La Laguna region, this integration also has involved multiple supporting organisations (see Figure 5.2), whose roles contributing to the development of capabilities of the region are analysed below.



Source: Author's elaboration.

Figure 5.2 Los Altos dairy system of innovation

a) Evolution of capabilities of the networks of dairy farmers in Los Altos

Milk production is an important social and economic activity in Jalisco because it involves a substantial share of the rural population, including producers of grains and forages. Dairy production in Jalisco was estimated to occur in approximately 16,000 of the 86,000[233] cattle farms in 2005. In 1999, it was estimated that 10% were large farms

[233] Estimate from UGR Jalisco (Arellano Leaño 2005, Valencia Zarazúa 2005).

(more than 80 cows in production), 20% medium-sized farms (between 21 and 80 cows in production) and 70% small farms (less than 20 cows in production) (Cervantes Escoto, Santoyo Cortés et al. 2001, p 169). These farms have increasingly introduced technological components following the intensive model to improve profitability[234] to counter the increased costs of inputs for milk production (Alvarez Macías 2005; Cervantes Escoto 2005; Ortíz 2005; Soltero Gardea 2005). However, the modernisation of Los Altos started with improvement to milk quality using collective chilling tanks, a development that was not without problems such as cross-contamination of milk and the increasing power of ‘ruteros’ in milk commercialisation (Cervantes Escoto, Santoyo Cortés et al. 2001).

Family systems are run mainly (80%) by the owner and family members with a strong dairy cattle tradition (Cervantes Escoto, Santoyo Cortés et al. 2001). These small farmers usually have low average education (Perez Burgos 2005) and are resistant to changing their farming practices. They are individualist and suspicious of collective efforts via farmers’ organisations (Ramírez González 2005a). In Jalisco they have been reluctant to use collective chilling tanks and mechanise milking to respond to new trading conditions (Rodríguez Gómez 2000).

Up to 1986, according to Rodríguez Gómez (1998a), the commercialisation of fresh milk was a complex process that led to at least three qualities of liquid milk:

a) High-quality chilled milk for production of pasteurised milk, flavoured milk, yogurt and mature cheeses;
b) non-chilled milk for production of artisan cheeses and milk-based regional confectionery, not adulterated with water or chemicals such as soda ash or Lactoperoxidase;[235]
c) non-chilled milk for industrial processes (e.g. evaporation, dehydration, and UHT process), without added water.

[234] It is estimated that approximately 40% of farmers do not profit from the activity (Cervantes Escoto, Santoyo Cortés et al. 2001).
[235] Lactoperoxidase is an enzyme, which delays the acidification of milk and is used to ‘cover’ poor hygiene practices in milking.

Farmers had differences in the use of chilling tanks and the commercialisation processes, which were either direct or via ‘ruteros’. For non-chilled milk, on delivery to the dairy facility, ‘ruteros’ negotiated the price with the dairy processor, based on quality. They discounted their transportation costs and commission and paid the dairy farmers the remainder. ‘Ruteros’ did not share price information, which gave them power over the milk producers, who had to accept what the ‘ruteros’ gave them due to an absence of alternative milk collections and/or distribution channels. Furthermore, ‘ruteros’ were reimbursed by government for adjustment of the increased prices demanded by dairy farmers. These practices led to poor integration of the value chain (Rodríguez Gómez and Chombo Morales 1998).

In the mid-1980s, Nestlé and Lechera Guadalajara imposed milk quality standards and demanded higher volumes from milk producers (McDonald 1997; Rodríguez Gómez 1998a; Cervantes Escoto, Alvarez Macías et al. 2001; Cervantes Escoto, Santoyo Cortés et al. 2001; McDonald 2001; Cervantes Escoto 2003). This created strong resistance among dairy farmers because most produced in very low volumes and had neither the capital nor access to credit to acquire and operate chilling tanks.[236] It resulted in the formation of cooperatives of farmers who chilled their milk collectively (i.e. sociedades de producción rural), and ‘solidarity’ groups (i.e. grupos solidarios). They sought support from the dairy processors, Jalisco government, including SARH (now SAGARPA), and BANRURAL, to set up collective chilling facilities and collectively transport the chilled milk (i.e. ‘Tanques Rancheros’ programme) (Rodriguez Gomez 1998, Cervantes Escoto Alvarez Macias et al 2001). This led to a large network of 700 chilling tanks each taking the production of around 30 dairy farmers in the temperate region[237] (McDonald 1997; McDonald 1998; Rodríguez Gómez 1998b; McDonald 1999; del Valle Rivera 2000; McDonald 2001). Approximately 3,200 small and medium-sized farmers had organised around 330 chilling tanks by 1995 in Jalisco, most of them located in the Los Altos region (Rodríguez Gómez 1998a). Dairy processors argued that a high quality standard for milk was important for competing in the global market and for reducing the imports of NFDM and dairy products (Rodríguez Gómez

[236] It has been argued that dairy processors exerted their power to impose their standards for the quality of milk and their way of commercialisation at the expense of the dairy farmers’ interests (Rodríguez Gómez 2005; Chombo Morales 2005; Cervantes Escoto 2005).
[237] This programme was also established in Michoacán and Guanajuato (Mc Donald 1997; Mc Donald 1998; Mc Donald 1999).

1998b; Cervantes Escoto, Alvarez Macías et al. 2001). Sigma Alimentos, Alimentos La Concordia, LICONSA and Parmalat took up the strategy when they set up operations in Los Altos in the mid-1990s.

These new organisations of associated dairy farmers modified the routines of the family farms to produce the quality required for chilled milk according to the timing, quality standards, quotas and prices imposed by dairy processors, without legal contracts (McDonald 1997; Rodríguez Gómez 2000). These associations 'obliged' farmers to improve the management of the herd and the production of feedstock (Soltero Gardea 2005).

These associations of farmers, however, encountered conflicts, negotiation and reconfiguration of the value chain (Rodríguez Gómez and Chombo Morales 1998; McDonald 2001). As a result, the number of 'ruteros'[238] declined as more dairy farmers were directly integrated into new networks. Whereas, in 1992, just 5% of the milk sold was chilled, by 1998, this had increased to 80%. In 1992, there were a few associations of dairy producers; by 1998, around 75% of dairy farmers were associated with collective chilling facilities (Rodríguez Gómez 1998b). However, few collective chilling tanks were still in operation in 2005. Most farmers prefer to work on their own because of their lack of trust in each other, which is a main feature of the Los Altos dairy farmers and has influenced the evolution to individually-owned tanks (Rodríguez Gómez 1998b). This suggests a major investment by individual dairy farms in chilled tanks during the 1998-2005 period, which has been supported mainly by large dairy firms in the region and other development organisations (see below), which created a second transition to individually-owned chilling tanks.

One of the most successful entrepreneurial associations of dairy farmers in Los Altos is the cooperative *Productores de Leche de Acatic, Sociedad Cooperativa Limitada (PROLEA)*, which started in the early 1980s. PROLEA owned 3% of the shares of Alimentos La Concordia. Its organizational model has attracted resources from Alianza para el Campo and FIRA to accomplish a project including improvement of grazing systems, supplying replacement heifers, and social projects. Its model has been imitated

[238] These agents are still important, however. By the time of the fieldwork, many 'ruteros' chill the milk and have chilled transport in Jalisco (Soltero Gardea 2005).

by other dairy farmer associations and has attracted foreign students to learn from it (Ramírez González 2005a) (see TableS5.4 for further information on the case).

Further pressure on the dairy farms to increase the volume of high-quality milk (e.g. Nestlé had a target of processing only chilled milk by 2000) (Enrigue Loera 2005) obliged farmers in the groups to improve the quality of their milk production. This determined the next change in the commercialisation of chilled milk, the use of individual tanks. The dairy farmers who had improved their practices wanted to abandon collective tanks to get away from those who had not improved and who were causing cross-contamination of the milk, decreased quality, and lower incomes for the farmers (Cervantes Escoto, Santoyo Cortés et al. 2001). The dairy processors and government organisations (i.e. FIRA and Alianza para el Campo) supported this change. For instance, in 1999, Lechera Guadalajara received milk from 148 collective tanks and 134 individual tanks (Cervantes Escoto, Alvarez Macías et al. 2001; Cervantes Escoto, Santoyo Cortés et al. 2001). The change to individual tanks was enabled by the availability in the market of different-sized tanks, promoted by Lechera Guadalajara and Nestlé (Enrigue Loera 2005; Hernández León 2005).

The use of individual tanks proved to be a better way of preserving milk quality compared to collective tanks (Cervantes Escoto, Alvarez Macías et al. 2001; Cervantes Escoto, Santoyo Cortés et al. 2001). By 2005, approximately 90% of the milk produced in the region was commercialised chilled, and the quality had improved substantially (Soltero Gardea 2005) (see also Table S5.5). This helped to extend the shelf life of artisan cheese (Falcón Estrada 2005; Guardado González 2005). But, on average, the quality of fresh milk was still lower than that collected by the national dairy leaders, Lala and Alpura in other regions (Soltero Gardea 2005).

It is estimated that most dairy farmers have introduced at least one other of the four major components of the Holstein model (Díaz Mora 2005; Pérez Burgos 2005). According to Cervantes Escoto, Santoyo Cortés et al. (2001), the four components of the model are: the use of artificial insemination; the use of alfalfa as a main source of forage; the use of mechanical milking; and an organisation to sell chilled milk. These changes made it possible to increase the productivity of the cows to between 14-23 litres/day/cow depending on the technological level of the farms (see Table S5.6).

Cervantes Escoto, Santoyo Cortés et al. (2001) found three technological levels of family farms to be present in Los Altos[239]:

1. Modern (13%): use artificial insemination and alfalfa as a main feedstock, the milking is mechanical and farms have individual or collective chilling tanks.
2. Medium (25%): use artificial insemination, but do not use alfalfa; they still use grazing and manual milking.
3. Traditional (62%): do not use artificial insemination or feed animals with alfalfa; some milk mechanically. Some chill the milk.

An important factor that lowers the profitability of family systems is the small scale of the farms. It is estimated that the minimum efficient scale of production is not less than 25 cows in production, with an average productivity of 20 litres/day and a minimum of 12 hectares for forage production (Cervantes Escoto, Santoyo Cortés et al. 2001; Soltero Gardea 2005).

A summary of the capabilities for milk production in the region and the mechanisms of development that affected some of the procedures and routines of the technological components of the specialised milk production system (see Table 4.7) is presented below. These changes led the region to increase the productivity of the cows to 14-23 litres/day and to integrate the value chain and commercialise approximately 90% of chilled milk.

Table 5.9 Los Altos capabilities for milk production and development mechanisms

Capabilities	Development mechanisms
Technological capabilities to improve the genetics of the herd	Increasing use of artificial insemination practices promoted and diffused by suppliers of semen and other inputs for animal reproduction. Around 38% use artificial insemination and 62% traditional methods using studs
Technological capabilities to improve herd management	Around 13% use alfalfa as main feedstock and 87% use a mix of grains, silages and grazing
Technological capabilities to improve milking systems and hygiene practices	Increasing use of mechanical milking system supported by suppliers of milking machines. Around 46% use mechanical milking and 54% manual
Organisational capabilities to integrate farmers to chill milk and commercialise it for industrialisation	Setting up of the chilling infrastructure supported by Nestlé, Lechera Guadalajara and Alimentos La Concordia and “Tanques Rancheros” programme and Alianza para el Campo programmes. Around 5% use individual chilling tanks and 81% use collective chilling tanks

Source: Author’s elaboration of data from Cervantes Escoto, Santoyo Cortés et al. (2001) (see Table S5.6).

[239] The following results come from an analysis of the data from Table S5.6.

In summary, integration of the value chain in Los Altos has been a long and (at the time of the fieldwork) still incomplete process. It has involved increasing use of technology for milk production in ways that move towards the specialisation model as well as attempts to restructure the system, increasing the scale of production to improve the profitability of the farms. However, it is incomplete because of the low economic capacity of farmers to update the technologies within farms to change their farming practices and culture, which is resistant to working collectively, although some successful dairy farmer associations have emerged (e.g. PROLEA). The case of individual chilling tanks indicates a reduced requirement for cooperation and the case for the benefits of cooperation aside from collective chilling has not been made.

b) Evolution of capabilities of Los Altos dairy processors

The Los Altos region includes approximately 33 dairy firms (Cervantes Escoto, Santoyo Cortés et al. 2001). By 2005, large and medium-sized dairy processors, Nestlé, Lechera Guadalajara, Alimentos La Concordia, and Sigma Alimentos (and recently Lala and Alpura),[240] collected approximately 87% of fresh milk. As explained above, these firms led the integration of dairy farmers to chill milk collectively, together with other government organisations and recently LICONSA, which has increased its participation in milk collection in the region to approximately 7% (see Table S5.7). However, LICONSA's role in supporting capabilities development (see further explanation in this section) is unclear.

While Lechera Guadalajara and Alimentos La Concordia are the two most important producers of pasteurised milk in Jalisco, Nestlé and Sigma Alimentos are the most important producers of cheese and yogurt in the region. They have developed dairy production capabilities but have also contributed to the development of the region's capabilities in different ways as will be explained below.

Nestlé[241] is the oldest dairy processor in the Los Altos (and in the tropical region, see Tabasco case) and one of the most important integrators of the dairy value chain since

[240] At the time of the fieldwork, the Parmalat facility was not operating and was functioning as a Lala distribution centre (Guardado González 2005). Alpura has no facilities in the region, but collects an important percentage of milk production (Cervantes Escoto, Santoyo Cortés et al. 2001).

[241] Most of the information on Nestlé is from its website and interviewees' opinions; executives in Nestlé Los Altos were not willing to be interviewed.

1935 when it set up operations in the region. By 2005, Nestlé had four dairy facilities in Jalisco to produce powdered milk, infant formula and ice cream and collected approximately 1 million litres per day of chilled milk in Los Altos (Falcón Estrada 2005).

Nestlé has influenced milk production in two ways: a) supporting the development of a network of milk suppliers that produce 100% chilled milk, which evolved from non-chilled milk, followed by chilled milk using collective chilled tanks (‘Tanques Rancheros’ programme) to collecting chilled milk using individual chilling tanks, throughout the 1980s to 2000;[242] and b) increasingly introducing the practices of the intensive model (Rodríguez Gómez and Alvarez Macías 1998; Cervantes Escoto, Alvarez Macías et al. 2001), which has created ‘awareness’ among dairy farmers to improve profits. It offers to farmers technical assistance to improve the management of the grazing and prairies, financial assistance for the acquisition of chilling tanks, milking systems and other inputs for animal nutrition and reproduction (i.e. semen and feedstock),[243] and rewards a premium price for chilled milk. Nestlé has joint projects with suppliers of inputs for animal husbandry to support the introduction of the intensive model, as well as a group of veterinarians and agronomists who assist dairy farmers (Enrigue Loera 2005; Ordóñez Vázquez 2005) (see further details in Appendix I, section 2.1).

In terms of dairy processing, Nestlé has no R&D department in Mexico,[244] except specific activities to adapt products to local tastes.[245] The firm is the leader in powdered milk, infant formula, condensed and evaporated milk, and shares the yogurt and cheese

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[242] Nestlé has participated with a local firm in the Los Altos region to design and produce chilling tanks of different capacities and with specific technical features to prevent loss of milk quality during the collection process (Enrigue Loera 2005).
[243] All these services are supplied at reduced prices and low interest rates compared with commercial market costs (Godínez Vázquez, 2005).
[244] Interviewees who were unwilling to be identified stated that Nestlé is not investing as much in milk development activities as it used to because since the NAFTA signing, the firm can import NFDM to produce dairy products and can import other dairy products to commercialise them in the country.
[245] Nestlé has Product Technology Centres (PTCs) in other countries, which conduct R&D for product and process innovation. Each PTC works in one specific business (i.e. coffee and beverages, confectionery, ice cream, infant nutrition products, culinary products) to serve the needs of the Nestlé Strategic Business Unit. PTCs around the world adapt products and processes to local tastes and needs. Certain products, e.g. powdered milks and infant formula are the same the world over, so whether product development is carried out in Switzerland or the US is of little importance. Nestlé Website: http://www.research.Nestlé.com/structure_network/the_network/Other_RD_Centers.htm (September 20, 2006).

market with Sigma Alimentos (i.e. Yoplait) and Danone (Euromonitor 2005). It is very active in marketing supported by its strong branding (10 main brands), and network of 21 distribution centres around the country (see Table 6.4), which commercialise a large portfolio of 36 types of dairy products. A summary of Nestlé capabilities and development mechanisms is provided in Table 5.10.

Table 5.10 Nestlé capabilities and development mechanisms

Capabilities	Development mechanisms
Technological capabilities supporting farmers to improve quality of milk and herd management Technological capabilities to produce new dairy processes and products	Technical assistance for dairy farmers including lab infrastructure and quality assurance procedures Supporting the production of chilling tanks with a Mexican firm in Jalisco R&D activities to adjust processes and products for the Mexican market

Sources: Author's elaboration.

The largest and most influential dairy firm in Jalisco is *Lechera Guadalajara, SA de CV* (Soltero Gardea 2005). It was set up in 1961 in Guadalajara to pasteurise and distribute pasteurised milk in a modern dairy facility. Since then, it has expanded to dairy production and by 2005 had increased production capacity and market through two new dairy facilities in Mazatlán in the state of Sinaloa and in Linares in the state of Nuevo León (Canedo Parra 2005).

The firm has nine subsidiaries (see Table S5.8), which provide inputs and services to Lechera Guadalajara, and owns 40% of the shares in Alimentos La Concordia located in Lagos de Moreno, which supplies chilled milk to Lechera Guadalajara (Ramírez González 2005b).

Lechera Guadalajara has developed 12 kinds of dairy products and is becoming a national dairy firm. It sells products in 23 states using a network of approximately 43 distribution centres and a well-positioned brand (i.e. Sello Rojo™)[246] (see Table 6.4). This is the result of a well-integrated network of family dairy farmers (with 20 to 25 cows in production at any one time). Although its number of suppliers has reduced to less than 25% (approximately 950, in 2005) of the total in 1994,[247] it has increased the

[246] Author's analysis of information from Lechera Guadalajara's website http://www.sellorojo.com.mx/nosotros-maquinas.html (September 18, 2006)
[247] Lechera Guadalajara plays an important social role in Jalisco in integrating small dairy farmers compared with other dairy firms, which have developed a *laissez faire* attitude, ignoring their social responsibility (de la Peña Marshall 2005).

collection of high quality chilled milk from farmers that have introduced technologies to improve productivity of cows from an average of 11 to 21 litres per day per cow and conservation of the quality of milk. The firm started collection of chilled milk, and has been using collective chilling tanks (Morales Reyes 2005) since 1984. Quality improvement has enabled the firm to achieve an increase in the shelf life of pasteurised milk from 3 to 14 days, which is an outstanding achievement for this type of product (Hernández León 2005).

Based on similar strategies to Lala and Nestlé to support farmers, Lechera Guadalajara provides discounted loans to dairy farmers for the purchase of individual chilling tanks. It has also developed a technical assistance service [248] with 25 veterinarians and agronomists, and supports international commercial dairy events, PROLECHE[249] and CIGAL, to promote best practice in animal health and nutrition. In 2005, it had a network of nine catchment centres,[250] which include milk quality laboratories (Morales Reyes 2005).

For dairy production, Lechera Guadalajara has a team of engineers with strong engineering capabilities, which together with its engineering subsidiaries (i.e. CEIBA, REEMPLASA and UYEDA) have designed and built dairy facilities (including one to dry surplus milk in Jalisco), developed packaging and plastic recycling systems, and developed information systems for plant operation control (Téllez Abaunza 2005). In addition, it has a R&D department with two professionals, which has developed functional dairy products. These groups work on joint projects with equipment suppliers (e.g. Uniloy, Tetrapak, Danisco, Störk, Combiblok, APV and TAV) as well as suppliers of food ingredients (e.g. Danisco, Rhodia, Sako, Takasago, Silessia, Firmenich and Helm de México, etc.) (Canedo Parra 2005) .

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[248] With the exception of assistance to improve cows' reproduction and productivity, for which technicians are engaged through separate contracts (Hernández León 2005).

[249] PROLECHE is a group of MNCs (i.e. Boehringer Ingelheim Vetmedica, SA de CV and DeLaval, SA), which collaborates with farmers to improve the quality of milk and to increase productivity on farms. PROLECHE holds commercial exhibitions and technical training programmes with Lechera Guadalajara, COFOCALEC, FIRA, Universidad de Guadalajara, etc., in Lagos de Moreno and in other dairy regions. This concept of collaborative work was successfully developed and implemented in Argentina in 1995 and has been operating in Mexico since 2001 (Callieri 2005).

[250] In 2005, Lechera Guadalajara milk catchments were located in the municipalities of San Julián, San Miguel, San Juan, Tepatitlán, Jalostotitlán, Zapotlanejo, Santa María, Higuerillas and Valle de Guadalupe (Morales Reyes 2005).

To support the development of its capabilities, the firm has established a few training programmes with Universidad de Guadalajara, and with other equipment suppliers, mainly MNCs for maintenance, supply chain and control processes (Téllez Abaunza 2005) and has worked with COFOCALEC (see development organisations in point *f* of this subsection) on standardisation of its products and processes (Soltero Gardea 2005). Its policy is to develop the capabilities within the firm. It is considered a follower of Lala and Alpura. It had no international alliance for technology transfer. Some of the firm's weaknesses seemed to be in the marketing areas and the centralised decision making, which make the changes in processes and markets slow (Canedo Parra 2005).

The main achievements of the firm are the development of a network of suppliers of high quality chilled milk, the expansion of its dairy production capacity in other regions, and its increasing participation in other markets. Its main capabilities and the mechanisms of development are summarised in Table 5.11.

Table 5.11 Lechera Guadalajara capabilities and development mechanisms

Capabilities	Development mechanisms
Technological capabilities supporting farmers to improve quality of milk and herd management Technological capabilities to produce new dairy products and processes Engineering capabilities with its subsidiaries	Technical assistance for dairy farmers including laboratory infrastructure and quality assurance procedures Developing the production of chilling tanks with a subsidiary Sponsoring PROLECHE and CIGAL fora Attending milk symposia and exhibitions in the US, Spain, France and Argentina and visits to cooperatives in Spain and Argentina Developing R&D activities and joint project subsidiaries and suppliers of machinery, equipment and dairy ingredients Joint projects with COFOCALEC and other suppliers of services for quality control processes, development of standards and testing laboratories to pursue ISO 9002 and HACCCP

Sources: Author's elaboration of information from Canedo Parra (2005); Hernández León (2005); Morales Reyes (2005); Soltero Gardea (2005); Téllez Abaunza (2005).

The increases in milk production in Los Altos led Lechera Guadalajara, PROLEA and a group of dairy farmers to set up *Alimentos La Concordia* in 1994 in Lagos de Moreno (Ramírez González 2005b). In 2005, *Alimentos La Concordia* was producing 11 types of dairy products, which were sold in a regional market encompassing seven states under its brand Al Día™ (see Table 6.4).

Alimentos La Concordia is in the process of improving operations and expanding its market. It has upgraded its chilling systems, established a R&D department with two researchers and developed in-house information systems for inventory control and distribution systems (Chávez Gómez 2005; Díaz Mora 2005; Guerrero Jiménez 2005; Ramírez González 2005b). The firm has achieved COFOCALEC certification for some of its products and is pursuing the ISO 9002 certification for its information systems (Chávez Gómez 2005).

The network of dairy farmers of *Alimentos La Concordia* fell from 4,000 members in 1996 to approximately 800 by 2005. Of these, 35 farmers were associated in three collective dairy farms. Despite the reduction in the number of milk suppliers, the volume of catchments has increased from 900,000 litres in 1996 to approximately 1,300,000 litres in 2005.[251] This reduction was part of a 'natural selection process' among milk suppliers who were willing to meet the standards of the firm by using chilling systems and who had improved their hygiene practices on the farm. This improved the general quality of the milk and increased the shelf life of pasteurised milk from 5 to 21 days under optimal refrigeration conditions (Díaz Mora 2005; Ramírez González 2005b).

The firm has supported dairy farmers' development since 1998 through an established livestock department to provide services in the areas of herd management using specific in-house developed software and forage production, and collaborates with the DEPAI and GGAVATT groups in the region. It also provides administrative support to farmers to access credit from Alianza para el Campo and FIRA and provides credit to its associates through FINCA[252] to acquire machinery and equipment to improve agricultural practices and buy chilling tanks (Díaz Mora 2005).

In dairy processing, *Alimento La Concordia* has been very fast in developing new products and processes (e.g. UHT cream, lactose free milk, set and drinking yogurt, flavoured milk, milk shakes, and dairy formulas) with a one-person R&D department. Nevertheless, the firm's culture is very traditional and it is considered to be a follower

[251] Alimentos La Concordia supplies chilled milk to Lechera Guadalajara, LICONSA and regional artisan cheese processors (Díaz Mora 2005, Ramírez González 2005b).

[252] The firm has an investment fund FINCA (Fondo de Inversión y Contingencia La Concordia) to supply credit to its farmers associated with additional resources from FIRCO (Ramírez González 2005b).

by its board of directors, lacking any strong marketing capabilities (Díaz Mora 2005; Guerrero Jiménez 2005; Ramírez González 2005b).

The main achievements of the firm are the development of a network of suppliers of high quality chilled milk and the fast development of dairy products. Its capabilities and development mechanisms are summarised in Table 5.12.

Table 5.12 Alimentos La Concordia capabilities and development mechanisms

Capabilities	Development mechanisms
Technological capabilities to improve the quality of milk in farms	Technical assistance to farmers Developing quality assurance systems including development of labs Development of data systems of milk suppliers
Technological capabilities to produce new products, processes and their standards	Developing R&D, operations and quality assurance activities Joint projects with suppliers of machinery and food ingredients, software and information systems Developing activities addressing certification of COFOCALEC for selected products and administrative procedures to pursue ISO 9002

Sources: Author's elaboration of information from Chávez Gómez (2005); Díaz Mora (2005); Guerrero Jiménez (2005); Ramírez González (2005b); Soltero Gardea (2005).

Attracted by the increasing production of milk in Los Altos, in 1995 Grupo Alfa[253] set up *Sigma Alimentos* dairy division to produce yogurt using technological and marketing alliances with the French firm Yoplait. Sigma Alimentos has achieved a market share of approximately 23% of the national market for yogurt estimated at $700 million in 2004. For cheese production, it acquired Grupo Chen (i.e. a larger domestic cheese producer) in 2003 and New Zealand Mexico in 2005 and has become the market leader in cheese. It is increasing its participation in butter and milk cream markets in Mexico and Central America using a strategy of firm acquisitions[254] (Sigma Alimentos 2004; Sigma Alimentos 2005).

To ensure a supply of high quality chilled milk, in 1997, *Sigma Alimentos* established a milk quality assurance programme with a group of six agronomists to advise farmers on how to improve milk production and productivity. It also provides low interest rate

[253] Grupo Alfa is one of the 20 largest industrial groups in Mexico. Its business units are: Sigma Alimentos meat and prepared foods division, Sigma Alimentos dairy division, Alpek (petrochemical and plastics production) and Nemek (aluminium auto part spares) (Expansion Editor 2005).

[254] In 2001 Sigma Alimentos bought Inlatec in Costa Rica, which has one of the largest cheese facilities in Latin America; and in 2003 acquired Sosúa in the Dominican Republic, which is the leader in the production of dairy and meat products (Sigma Alimentos 2005).

credit as a 'para financiera'[255] with FIRA (Ortíz 2005; Quintanilla Alvarez 2006) (see Appendix I, section 1.3). One of the main achievements of the programme has been the support to 107 individual farmers and 32 groups of cooperatives of dairy farmers (i.e. Sociedades de Producción de Rural, SPR) to improve the productivity of the herds (Ortíz 2005). From 1995 to 2005, the number of groups of dairy farmers decreased 40% and the number of individual suppliers increased more than 10-fold (see Table S5.9) (Quintanilla Alvarez 2006).

According to Quintanilla Alvarez (2006), *Sigma Alimentos*' business drivers are dairy product innovation and strategic commercialisation with strong branding. It employs a wide array of dairy technologies to produce 36 types of cheeses and yogurts following international trends in dairy technologies (e.g. functional and dietetic yogurt with antioxidant and anti-stress effects) (see Table 6.4). It has an R&D technology centre with approximately 20 professionals with a laboratory and a pilot plant in Nuevo León for joint product development with national[256] and international suppliers. It has a department for development of human capital, operations and quality systems and a well-developed market research area to assess and implement new projects and products. Its main achievements are the development of a network of high quality chilled milk suppliers and rapid development of dairy products to become one of the national leaders in cheese and yogurt. Its capabilities and development mechanisms are summarised in Table 5.13.

Table 5.13 Sigma Alimentos capabilities and development mechanisms

Capabilities	Development mechanisms
Technological capabilities to develop networks of suppliers of high quality chilled milk R&D capabilities to develop dairy products, processes and their standards	Technical assistance to dairy farmers Developing quality assurance programme and certification with dairy farmers Technological alliances with foreign suppliers (e.g. Yoplait) Developing R&D department for dairy technology Developing operation and quality procedures to obtain the certification of ISO 9001-2000, HCCCP and PROFEPA Joint projects with suppliers of software and information systems (i.e. SAP, SAP QM and Sodima)

Sources: Author's elaboration of information from Quintanilla Alvarez (2006); Ortíz (2005).

[255] 'para financiera' or financial intermediaries in this case are agribusinesses serving as lenders to complement financial organisations' arrangements (e.g. FIRA).

[256] CONACYT provided economic support to Sigma Alimentos through its development programme for agribusiness development, 'Fondos Sectoriales en Materia Agrícola, Pecuaria, Acuacultura, Agrobiotecnología y Recursos Fitogenéticos'. http://148.207.1.2/Fondos/Sectoriales/SAGARPA/2004_01/SAGARPA_ResultadosPrepropuestas_2004-01.html (December 15, 2006).

In addition to the above-mentioned commercial dairy firms, *LICONSA* (see Appendix I, section 1.4 for further information on the firm) has played a controversial role in the market for fresh milk in Los Altos (and other dairy regions). The presence of LICONSA in the regions has stimulated the creation of a network of milk suppliers, which in 2005, supplied approximately 50% of its milk catchments based on its offering higher prices for fresh milk than the other dairy processors. Most of its suppliers are located within 5 km distance of LICONSA's nine (out of 38 in the country) collection centres in Jalisco (LICONSA 2005a; LICONSA 2005b; LICONSA 2005c). It has updated its laboratories to assure minimum quality standards for raw fresh milk and final products (LICONSA 2005b) and has achieved an average of 120 minutes for reductase testing for its milk quality catchments (LICONSA 2004). These changes have helped to improve the quality of LICONSA's final products (Aragón Mladosich and Gómez Ibañez 2004; Gallardo Jiménez 2005; Guerra Márquez 2005b). However, LICONSA's presence in Los Altos has been highly criticised by the other dairy processors who argue that the firm is distorting price and availability of milk in the region (Aragón Mladosich and Gómez Ibañez 2004). Furthermore, they argue that this has not helped farmers improve farmers' practices. However, the volume of its catchments in the region (approximately 4.5% of total milk production in Jalisco in 2004)[257] although higher than in other regions, does not seem to justify these claims.

In addition to the large dairy processors, Los Altos has an important group of family-owned firms and artisan cheese producers (called "cremerías and queserías") that produce different types of fresh cream, cheese, and milk-based confectionery from non-pasteurised milk and milk proteins (e.g. casein and caseinate powder and whey and milk preparations) for the low-income population. Some of those products are commercialised unbranded and in bulk, through intermediaries that distribute them regionally and in the large central markets, street markets around the main large cities in Mexico.

It has been argued that these firms have distorted the dairy market because they mislead the consumers. This claim is because their products are not based entirely on fresh milk (Cevallos Urueta 2005; García González 2005). However, it has also been

[257] Author's estimation: catchments of LICONSA, 76.517 million litres (LICONSA 2005a) out of a total of 1,701 million for the whole of Jalisco, by 2004.

argued that these firms are important for providing 'cheap dairy products' for those segments of the population that otherwise could not afford to buy dairy products (Anaya Zermeño 2005; Guardado González 2005). One example is *Lácteos Deshidratados Mexicanos, LDM*.

LDM is one of the oldest family-owned small dairy firms in the region set up in the early 1960s to produce fresh, mature and semi-mature cheeses using fresh milk and imported sodium caseinates to decrease the costs of production. By 2005, the firm has two main businesses: production of fresh cheese (e.g. type of Asadero, Sierra and Panela) for the Mexico City and US markets, and has diversified into dehydrating surplus milk since 1976 for Nestlé and Mead Johnson, and milk whey for industrial[258] and environmental[259] purposes. The firm has no R&D department and relies on the experience of its owners and personnel to develop its cheese technologies (Anaya Zermeño 2005; Guardado González 2005). Its main achievement is improving the quality of its cheese products, based on improved milk quality and processing improvements (Guardado González 2005). Its capabilities and development mechanisms are summarised in Table 5.14.

Table 5.14 LDM capabilities and development mechanisms

Capabilities	Development mechanisms
Technological capabilities to improve cheese and dairy production	Helping farmers to improve the procedures to collect high quality chilled milk Developing technologies to produce fresh and mature cheeses Developing information control systems for production and commercialisation Developing commercialisation channels in Mexico City and US export markets for butter and Manchego type cheese Training programmes to obtain certification of ISO 9001 in 2000 and HACCCP

Source: Author's elaboration of information from Anaya Zermeño (2005); Guardado González (2005).

Finally, there is an important social group of artisan cheese producers that produces the 'Cotija' cheese, the most popular semi-mature cheese in Los Altos and 'El Bajío' region.[260]. CIATEJ (see below in *e*) has provided training and technical support to these producers (many of whom are also farmers) to improve the quality of milk and their

[258] Milk whey is an important industrial product used widely for production of ice cream, milk shakes, bakery and regional dairy confectionery and animal feedstock.
[259] Milk whey cannot be disposed of in the sewerage system because it stimulates bacteriological activity, negating the sewage treatment at the plants; if discharged into rivers or lakes it reduces the oxygen content of water, which is fatal to fish and other aquatic organisms. PROFEPA regulation obliges cheese producers to dehydrate it.
[260] 'El Bajío' (the lowlands) region comprises parts of the states of Michoacán, Guanajuato and Querétaro.

cheese production processes (Chombo Morales 2005); and in 2005, a group of them were awarded a Protected Designation of Origin, PDO for 'Cotija'cheese (Gobierno de Jalisco 2005).[261]

c) Role of the network of suppliers of inputs and services in improving capabilities

Jalisco and Los Altos like La Laguna have well developed and integrated networks of suppliers of inputs for agriculture, milk and dairy production, which have influenced the modernisation processes in several ways:

a) delivering training courses and holding technical conferences (e.g. PROLECHE and CIGAL) to update milk and dairy technologies and to develop technologies for intensive grazing systems and feedstock production This involves MNCs (e.g. WestfaliaSurge, Alfa Laval and Bossio) and national firms (e.g. Madero Equipos de Ordeño and Ordemex[262]) (Callieri 2005; Lamas de los Reyes 2005; Madero Gámez 2005; Pérez Burgos 2005; Soltero Gardea 2005), and
b) diagnostic and cattle disease control services (i.e. PRODEVIT)[263], which contribute to the achievements of SENASICA.

The network of domestic equipment suppliers is small and it has been argued that that there is little possibility of growth (e.g. production of chilling tanks and basic dairy machinery) (Enrigue Loera 2005; López López 2005), because a) the national firms have low technological development (e.g. lack of systems integration and automation, poor capacity for industrial design, etc.), which has not allowed them to compete in the national and international markets (Anaya Zermeño 2005; Guardado González 2005), and b) the size of the market is very small (Reinert Fernández 2005). This latter argument seems to lack support, since the presence of dairy suppliers has increased and is expected to continue to grow (Callieri 2005; Caraveo Márquez 2005).

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[261] 'Queso Cotija, Región de Origen' is the first PDO for an artisan cheese in the region comprised of several municipalities of Jalisco and Michoacán.

[262] Ordemex (Ordeñadoras de Mexico, SA de CV) is a national producer of milking systems for small farms. The firm receives no support from government to develop the market and has been banned as a supplier in the Alianza para el Campo programme (Lamas de los Reyes 2005).

[263] PRODEVIT is an international joint project of the Mexican and Japanese governments, which has established regional laboratory services to improve diagnosis and animal health in Jalisco (Proyecto para el Mejoramiento de los Servicios Regionales de Diagnóstico Veterinario en el Estado de Jalisco). PRODEVIT web site: http://project.jica.go.jp/mexico/2451084E0/spanish/news/ (March 30, 2006).

As in the case of La Laguna region, Los Altos region also faces heavy dependence on foreign suppliers of inputs for milk and dairy production, which also makes the region at risk if the economic conditions worsen. Furthermore, it has been suggested that regional suppliers of inputs would be an important project to speed up the advance of the modernisation of the small farmers. For instance, the development of a cow breed that would be more suitable for the region; and the production of milking machines with lower capacities than those produced by international suppliers (Lamas de los Reyes 2005; Pérez Burgos 2005; Soltero Gardea 2005; Ramírez González 2005a; Ramírez González 2005b).

d) Role of the network of financial suppliers in improving capabilities

*FIRA´*s regional office in Los Altos has systematically used its value network model, (see Appendix I, section 1.3) to analyse farmers' and supporting actors' activities and to identify their economic needs. Nevertheless, its participation has been limited to providing economic resources mainly to large farmers to improve their milk production infrastructures (i.e. mechanisation of agriculture, acquisition of milking systems and heifers); and providing resources through regional 'para financieras' (e.g. Sigma Alimentos and Nestlé). Similar to FIRA, *Financiera Rural* has financed the modernisation of agricultural mechanisation for large farmers (Falcón Estrada 2005; Pérez Burgos 2005).

e) Role of the universities and the regional research centres in improving capabilities

Jalisco has an important network of *universities and colleges* with programmes in agriculture, veterinary science, business and management. [264] However, these institutions have not upgraded their undergraduate, graduate and research programmes to support milk and dairy technologies and agribusinesses. Historically, they have had a few formal interactions with dairy farmers and dairy processors (Polanco Jaime and Chiwo Gallegos 1999) (e.g. undergraduate internships on dairy farms and in dairy firms, PROLEA, Lechera Guadalajara and Sigma Alimentos) (Morales Reyes 2005; Ortíz 2005; Ramírez González 2005a). However, there were no master programmes in dairy technologies, despite the importance of the sector in the region.

[264] One reason is that Jalisco is one of the three largest state economies in Mexico. However, most of its universities are located in Guadalajara, e.g. Universidad Autónoma de Jalisco, ITESM, Campus Guadalajara, Instituto Tecnológico de Occidente, ITESO, and a few have campuses in Los Altos, e.g. Universidad de Guadalajara and Centro Universitario Los Altos.

Some exceptional research on dairy development in Los Altos has been carried out by the sociology and anthropology research centre, Centro de Investigaciones y Estudios Superiores en Antropología Social, CIESAS (Rodríguez Gómez 2000) and multidisciplinary groups of technologists at CIATEJ (Rodríguez Gómez and Chombo Morales 1998), economists from UNAM and UAM (Martínez Borrego, Alvarez Macías et al. 1999; del Valle Rivera 2000; Martínez Borrego, Salas Quintanal et al. 2003), and technologists from COLPOS (in Estado de México), which are not located in the region (Cervantes Escoto and Alvarez Macías 2001; Cervantes Escoto, Alvarez Macías et al. 2001; Cervantes Escoto, Santoyo Cortés et al. 2001; Cervantes Escoto 2003) and have informed the present research.

The *Centro de Investigación y Asistencia Tecnológica y Diseño del Estado de Jalisco, CIATEJ*, set up in 1976 in Guadalajara, conducts research to support Jalisco's shoe and garment industries. Since 1982, CIATEJ has also provided support for agro industry innovation to improve competitiveness. It has a dairy pilot plant and laboratories for dairy and has conducted research on changes in perceptions of milk quality in the region. It has carried out technology transfer processes to improve artisan cheese production in Jalisco and Tabasco (see the case of Tabasco for artisan 'de Poro' cheese production) (Chombo Morales 1998; Chombo Morales 1999; Chombo Morales 2005) and has provided advice to financial organisations to support dairy farmers. The main achievements of CIATEJ have supported the development of the value chain for 'Cotija'cheese, which achieved the PDO 'Queso Cotija, Region de Origen' by 2006. The capabilities and building mechanisms are summarised in Table 5.15.

Table 5.15 CIATEJ capabilities and development mechanisms

Capabilities	Development mechanisms
Technological capabilities for regional cheese production	Technology transfer and standardisation of production processes for the 'Cotija' and 'de Poro' cheeses Advising financial actors in the technology transfer process to support small dairy processors Developing joint projects in dairy with universities and research organisations Developing research about the contested issue of milk quality in the western region of Mexico

Source: Author's elaboration of information from Chombo Morales (2005).

f) Role of the organisations for regional development

Jalisco has a complex network of organisations dealing with agriculture and rural development, which have contributed to the evolution of the capabilities in Los Altos. According to Pérez Burgos (2005), the *Fundación Produce Jalisco (FUNPROJAL)* has promoted the processes of learning by doing and sharing among dairy farmers to improve their productivity and competitiveness through collaborative working with other organisations, in the following projects:

1. farmers' training programme carried out with SEDAGRO,[265] the state council for milk production (i.e. Consejo Estatal de la Leche de Jalisco), FIRA, UGR Jalisco, CIPEJ (see below) and SEDER[266] under the Alianza para el Campo programme (i.e. DEPAI programme);
2. technical visits to dairy farmers in the US and Canada, which inspired PROLEA to organise collective farms to achieve a profitable scale;
3. a joint technological project with Universidad de Guadalajara to produce compost using worm culture, which started in 2002 and has achieved some results. However, it has not yet reached the stage of commercialisation.

Another influential organisation is the *Jalisco cattlemen's association, Union Ganadera Regional de Jalisco (UGR Jalisco).* This is the oldest Jalisco livestock producers' association, which was set up in 1955. In 2005, it had 132 branches with approximately 105,000 members, but poor representation of dairy farmers (approximately 16,000) except in the Los Altos region (Pérez Burgos 2005), where the dairy farmers led the local associations (Gallardo Jiménez 2005; Guerra Márquez 2005a).

UGR Jalisco has collaborated to implement the DEPAI programme to introduce dairy technology following the intensive model (Arellano Leaño 2005; Valencia Zarazúa 2005). It provides workshops to develop awareness among dairy farmers of the implication of NAFTA for dairy and to develop a network of suppliers for forage and grains. However, lack of trust among members of the local associations, absence of extension agents from DEPAI and lack of procedures on farms to monitor and codify

[265] SEDAGRO Jalisco is the administrative government office of Jalisco for planning and implementing agricultural and forestry policies to address economic and social sustainability for secure food supply. It comes under SAGARPA.
[266] SEDER is the Secretaria de Desarrollo Rural, i.e. Secretary of Rural Development.

the results of projects have restricted the success of the DEPAI method (Arellano Leaño 2005; Pérez Burgos 2005; Valencia Zarazúa 2005).

Another organisation for development of dairy farmers is *Jalisco Desarrollo y Fomento, JADEFO*. It is an entrepreneurs' association set up in 1974 to encourage rural development under Fundación Mexicana para el Desarrollo Rural, AC. *JADEFO* has since 2000 coordinated the human and economic resources of Alianza para el Campo to carry out the DEPAI method. The DEPAI programme provided 22 agriculture extension agents (see projects of the *UGR Jalisco* and *FUNPROJAL*) to set up approximately 27 collective farms (i.e. 'establos colectivos') with groups of approximately 10 small farmers[267] to commercialise chilled milk, but very few have succeeded. In addition to the farmers' inability to work collectively, resources to follow up the DEPAI groups have been limited (Valencia Zarazúa 2005). However, *JADEFO* has succeeded with a project to construct grain storage silos to produce silage to ensure the availability of grains aimed at reducing milk production costs. In 2005, this project was benefiting more than six groups of associated dairy farmers (JADEFO 2005).

Another organisation that supports farmers' development is the *Centro de Investigaciones Pecuarias del Estado de Jalisco, CIPEJ*. It is a civil association constituted by SEDER, UGR Jalisco and INIFAP Jalisco. CIPEJ has been working to improve herd genetics with pure Holstein and Jersey heifers and artificial insemination within government programmes ('Ganado Mejor' and 'Mejoramiento Genético'), and crossbreeds for the tropical region of Jalisco on the west coast (de la Torre Sánchez 2005; Reynosa Campos 2005). It also collaborates with DEPAI and GGAVATT groups in Los Altos.

In terms of standardisation of the dairy industry in the region and at national level, the *Comision para el Fomento y la Calidad de la Leche y sus Derivados, AC, COFOCALEC* has been operating since 1997. COFOCALEC is located in Guadalajara and since 2001 it has been actively involved in national committees for the standardisation of dairy products and dairy processing. It has developed the technical infrastructure for dairy quality assessment and developed national standards for milk

[267] JADEFO and UGR Jalisco promoted implementation of the 'Tanques Rancheros' programme in the mid-1990s (JADEFO 2005).

and dairy products and processes, and dairy test laboratories. It offers technical services for: a) milk and dairy products processes certification; b) inspection and assessment of milk and dairy facilities; c) training courses for standardisation on farms and in dairy facilities; and d) dairy testing laboratories for standardisation. It also participates in CIGAL and diffuses dairy topics through its dairy bulletin (Soltero Gardea 2005).

In 2002, COFOCALEC received approval from SAGARPA as a national organisation for standardisation in the milk production system (Organismo Nacional de Normalización del Sistema Producto Bovino Leche, ONNSPBL), and certification from the Mexican accreditation authority (Entidad Mexicana de Acreditacion, EMA[268]) and from the Mexican office for standardisation (i.e. Dirección General de Normas, DGN) [269] (see examples in Table S5.10) and is working with international organisations[270] on international dairy standards. COFOCALEC has contributed to the standardisation of the Jalisco dairy industry; however, it has not achieved national reach (Soltero Gardea 2005). A summary of the capabilities supported by COFOCALEC and the building mechanisms are presented in Table 5.16.

Table 5.16 COFOCALEC capabilities and development mechanisms

Capabilities	Building mechanisms
Development and diffusion of milk and dairy standardisation in dairy farms and firms	Developing a national and international network for standardisation of the dairy industry Setting up laboratories and delivering services for quality assessment, insurance in milk and dairy facilities, milk and dairy products certification Training programmes to develop a network of dairy farmers Producing and distributing a dairy bulletin for dairy standardisation

Source: Author's elaboration of information from Soltero Gardea (2005).

[268] EMA is a private Mexican organisation for accreditation of other organisations involved in the insurance of testing labs, metrology, certification organisations, and units of assessment for international trade in products and services. EMA website http://www.ema.org.mx/index1024.htm (February 20, 2006).

[269] DGN is the Mexican office under the Secretary of Economy responsible for development and enforcement of standardisation in the manufactured products.
DGN website http://www.economia.gob.mx/index.jsp?P=104 (February 20, 2006).

[270] These include: Comisión Nacional de Normalización (CNN), Dirección General de Normas (DGN-SE), Comité Mexicano para atención de la ISO, Comité Mexicano para atención del CODEX Alimentarius, Comité Mexicano para Atención de la COPANT, Consejo Mexicano de Normalización y Evaluación de la Conformidad (COMENOR) and México Calidad Suprema, MCS, which is the trademark for high quality, safe Mexican products. It was developed by the association of the Secretary of Economy, BANCOMEXT and SAGARPA to promote the export of agricultural products. MCS website http://www.mexicocalidadsuprema.com/index.jsp?P=47 (February 10, 2006).

One of the main problems in expanding standardisation and certification in the dairy industry is that the certification of dairy farms and firms is not compulsory. Dairy firms, especially the small ones, do not perceive certification as offering any economic benefit, while being costly and requiring implementation of processes and product controls that they resist. There has been recurrent conflict between dairy firms and PROFECO in the enforcement of dairy standards (Soltero Gardea 2005). PROFECO has identified the failures of the dairy firms to fulfil the requirements of quality and labelling, and has denounced them in their bulletins (PROFECO 2002; PROFECO 2005; PROFECO 2005). However, they have not resorted to legal action because government organisations in charge of the enforcement of the standards (i.e. Secretary of Health and Secretary of Economy) do not have the infrastructure and resources to do this. This is an ongoing conflict in the region and a national problem (Soltero Gardea 2005).

In summary, it seems that there has been an improvement in milk production practices, which has led to increased milk production and improved milk quality in Los Altos (and Jalisco). This has attracted new dairy processors (i.e. Alimentos La Concordia, Sigma Alimentos and LICONSA), which have increasingly integrated small dairy farmers, who have managed to deliver the quality of chilled milk required. Nonetheless, the large dairy processors coexist with a significant group of small artisan dairy processors and the transition to an intensive model of milk production is incomplete. The next subsection describes the main achievements of the Los Altos dairy system and assesses the collective roles of the actors in improving the capabilities of the dairy region in terms of functions and dysfunctions.

5.2.3 Functions and dysfunctions: assessing the role of the actors involved in capabilities building in Los Altos dairy region

Dairy production in Los Altos has a more complex structure of production and development than in La Laguna. It has a large population of small dairy farmers (approximately 16,000) integrated with a few large dairy firms and numerous small artisan producers. The transformation of milk production systems has involved the gradual introduction of technological and organisational practices of the intensive model which began before NAFTA and has reached 38% of farms (Cervantes Escoto, Santoyo Cortés et al. 2001). Numerous firms and non-profit organisations have participated in this transformation process, which has involved a decentralised coordination of the mechanisms that created learning processes to improve capabilities of farmers, which can be summarised as follow:

a) Lechera Guadalajara, Nestlé, Sigma Alimentos and Alimentos la Concordia have provided technical assistance to farmers, through their technical departments and financial support;
b) FUNPROJAL, JADEFO, UGR Jalisco, SEDAGRO, SEDER, CIPEJ and CIATEJ have provided training courses and extension activities (e.g. DEPAI and GGAVATT groups);
c) technical events CIGAL and PROLECHE from international agriculture and dairy suppliers.

It could be said that the Los Altos dairy system has accumulated the following capabilities for milk production (see Table 5.17).

Table 5.17 Los Altos dairy system capabilities for milk production and commercialisation

Technological capabilities	Organisational capabilities
Adapting Holstein model practices Developing the technical infrastructure to standardise raw fresh milk for industrial purposes and dairy products and processes Research capabilities (e.g. CIESAS, COLPOS, UAM and UNAM)	Developing networks of suppliers of high quality chilled milk Developing operational capabilities for animal health diseases eradication Developing networks of suppliers for grains and forage

Source: Author's elaboration.

Dairy processing has improved and most dairy firms have improved their capabilities to improve, develop and introduce new products into the regional and national markets and have even introduced production facilities into other countries (the case of Sigma Alimentos) and won significant shares of these markets. Some of the mechanisms of the collaborative learning processes to create these capabilities are:

a) R&D efforts of the dairy firms Lechera Guadalajara, Alimentos La Concordia and LDM; and joint projects with suppliers of technologies to produce new products (e.g. technological alliances of Sigma Alimentos and possibly Nestlé);
b) improving artisan cheese-making practices to get PDO (i.e. CIATEJ and 'Cotija' cheese producers); and

c) systematic activities for the standardisation of dairy products and processes (i.e. COFOCALEC and dairy firms).

The main capabilities for dairy production are presented in Table 5.18.

Table 5.18 Los Altos dairy system capabilities for dairy production

Technological capabilities	Organisational capabilities
Developing R&D capabilities for new products development	Developing institutions to support the industrial standardisation of dairy production
Developing quality control operational systems	Developing PDO for 'Cotija' cheese
Developing technical infrastructure for standardisation of dairy products and processes	Developing alliances for technology transfer and franchising

Source: Author's elaboration.

As noted in Table 5.9, improvement in the capabilities of the regions has contributed to the economic results for milk production, which in the period 1994-2004 show that Jalisco maintained its share in national milk production (i.e. 17.18% in 1994 and 17.23% in 2004). This growth was slightly higher than the national one (3.07% vs. 3.04%), but lower than for dairy cattle (i.e. 8.63% of the region) (see Table 6.1). This suggests that average productivity per cow has not improved. However, the Los Altos region is responsible for 62% of Jalisco's production (in 2004) and five municipalities produced more than 50% of milk with an estimated 36% of the Jalisco dairy herd (SEDAGRO 2005). This strongly suggests that average productivity per cow in the Los Altos region has increased (Arellano Leaño 2005; Cevallos Urueta 2005).

Some of the achievements of the region can be summarised as follows:

1. Increased modernisation of the infrastructure for mechanical milking and chilling milk systems, which has led to a network of dairy farms producing high quality chilled milk for the large dairy firms, which collect 100% chilled milk for industrialisation.
2. Establishment of new dairy firms (i.e. Alimentos La Concordia, Sigma Alimentos and Parmalat) and other buyers of fresh milk (i.e. Alpura, Lala and LICONSA).
3. Development of the infrastructure for standardisation of the dairy industry.
4. Improvement of artisan cheese making, including certification from PDO for the'Cotija'cheese.

Blocking mechanisms and constraints for capabilities building

In addition to the insufficient irrigation infrastructure in Jalisco to satisfy the growing demand for animal feed in the Los Altos region (Pérez Burgos 2005), there were also some constraints in the systems for capabilities building, which include:

1. lack of trust among farmers, which impedes achievement of a sufficient scale of production to improve the profitability of farms (e.g. collective farms);
2. traditional culture and low levels of education among farmers which delays the introduction of technology;
3. development of the dairy market with milk substitutes which is distorting the market;[271]
4. heavy dependence on family labour and remittances, which threatens the profitability and sustainability of the system over the long term.

Table 5.19 summarises the evidence from an analysis on the collective activities of different actors that contributed to capabilities development supporting functions as well as the blocking mechanisms and constraints that have impeded the development of capabilities and led to dysfunctions.

[271] In 1998-1999 COFOCALEC did some research with Nielsen to identify the bases of the sources of choice in the purchase of dairy products and found that more than 75% of consumers do not read the labels on processed food. They rely on advertising and price, which can be misleading and do not help the development of standards in the region and the MDS because of lack of nationwide institutions for dairy standardisation (Soltero Gardea 2005).

Table 5.19 Los Altos dairy system's functions and dysfunctions

Functions	Dysfunctions
Creating and diffusing new knowledge	
Diffusing milk production practices and dairy technologies (DEPAI and GGAVATT groups, CIGAL, PROLECHE, CIPEJ, CIATEJ, SEDAGRO, FUNPROJAL, JADEFO, UGR Jalisco, COFOCALEC) Innovative R&D capabilities to develop new dairy production (Lechera Guadalajara, Sigma Alimentos, Alimentos La Concordia and LDM) and to search for technology transfer alliances (Sigma Alimentos) Developing some services for herd management (Alimentos La Concordia, Nestlé, Lechera Guadalajara)	Insufficient training to improve human capabilities in numerous family farms (e.g. herd management, intensive grazing practices, hygienic practices, etc.) and artisan cheese production aimed at increasing profitability of the units of production
Driving research process	
Creating organisations to influence the regional milk and dairy production (FUNPROJAL, UACh, COFOCALEC, SEDAGRO, Consejo Estatal de la Leche de Jalisco and CIPEJ) Developing joint research in the Los Altos dairy system (CIESAS, COLPOS, and UNAM)	Lack of institutions to set up strategic economic and social bases for the sustainability of the family dairy farms (e.g. production of inputs, associations of farmers or collective farms, scale of production and farm profitability)
Entrepreneurial experimentation	
Firms' innovative activities to expand production capacity in the region and other states (Lechera Guadalajara) and the setting up of new dairy firms (Sigma Alimentos and Parmalat, now Lala) Creating a network of feedstock and heifers suppliers (UGR Jalisco, local cattlemen associations, JADEFO and PROLEA)	Weak networks to develop regional domestic suppliers of inputs for agriculture and milk production (e.g. specialised heifer production and semen production), which can support family systems to reduce the risk of increasing production costs due to foreign input dependency
Facilitating the formation of the markets	
Developing networks of dairy farmers with high quality chilled milk (i.e. Lechera Guadalajara, Alimentos La Concordia, Sigma Alimentos, and Nestlé and LICONSA)	The apparent distortion of the price and demand of the fresh milk by LICONSA The distortion of the market by dairy products produced with milk protein and food additives
Creating positive externalities	
Changing research infrastructure to attend to the demand of farmers (FUNPROJAL, SEDAGRO, SEDER) Developing institutions for animal diseases control (dairy farmers, SEDAGRO, PRODEVIT, SENASICA, UGR Jalisco) Creating a network of feedstock and heifer suppliers (UGR Jalisco, local cattlemen associations, JADEFO and PROLEA) Attracting new dairy firms (Sigma Alimentos, Alimentos La Concordia and Parmalat) and suppliers for dairy and agriculture Creating alliances with other firms for dairy production (e.g. Sigma Alimentos)	Lack of political instruments to deal with the scale of production problem and the profitability of family farms Lack of institutions to upgrade educational university programmes to deal with the demands of agribusiness Displacement of dairy farmers and resulting social problems Weak institutional set-up to assess and mitigate the effects of the entry of subsidised NFDM and milk protein and to mitigate the seasonality of milk production prices
Legitimation	
Increasing introduction of Holstein model technological components in family farms Developing a culture of chilled milk (dairy farmers, government organisations and dairy firms) Creating COFOCALEC to standardise milk and dairy production Development of a regional artisan cheese industry (i.e. 'Cotija' cheese) including its PDO (CIATEJ and artisan cheese producers)	Weak institutional set-up to deal with regional and nationwide normalisation and standardisation of dairy farms and dairy processors including artisan cheese production due to the lack of organisations to enforce the process, and the perception of the farmers and firms that such standardisation is not adding value to their products
Mobilising resources	
Providing public and private investment for the modernisation of the system (Alianza para el Campo, dairy farmers, FIRA, Lechera Guadalajara, Sigma Alimentos, Alimentos La Concordia, Nestlé and the remittances of labour from the US)	Limited economic and institutional support for the modernisation of numerous family dairy farmers

Source: Author's elaboration.

5.3 Tropical region and the dual-purpose milk production systems: the case of Tabasco state

Tabasco milk production and industrialisation have evolved from a dominance of beef cattle to a modest level of milk and dairy production beginning in the 1970s, in part due to the Chontalpa plan project.[272] This project included the objective of economic sustainability in milk production using dual-purpose systems in the tropical region[273] (Aranda Ibáñez 2005). Not until the Mexican economic crisis of the 1980s did the Tabasco government and the dairy farmers start to modernise the dairy industry with the installation of a dairy facility (i.e. Ultralácteos) to pasteurise and commercialise the milk produced in Tabasco (del Valle Rivera 2000).

The Federal government and other development organisations have identified Mexico's tropical region as having high potential for milk production based on its water supplies and grasslands (Avila Pacheco 1991; Romero Villanueva 2005). However, dairy farmers and dairy processors are struggling to develop capabilities for modernisation and it is not clear what the actors in the system want to achieve, how they want to do it and when it will happen.

5.3.1 Modernisation of Tabasco dairy system and NAFTA

Increasing the production of milk in Tabasco has been a difficult process involving the introduction of specialised dairy cows into a rustic production system (i.e. Chontalpa plan project) and increasingly crossbreeds of specialised dairy cows and Zebu and Creole cows (Aranda Ibáñez 2005) (see subsection 2.3.1). Therefore, the developments following NAFTA highlighted not only the technological disadvantages of dairy farmers, but also additional difficulties in the region. First, dairy farmers, especially small ones, were not involved in the NAFTA negotiations; thus, many were not aware of its implications. They were unable to cope with the increased imports of cheaper and subsidised dairy products or to adjust to the changing demands of consumers (i.e. higher

[272] This was the introduction of the 'rejeguerías' which are combined beef and milk cattle units. The traditional cattle in tropical areas, Zebu and Creole cows, produced mainly beef on extensive grazing land. Exceptionally productive cows were able to feed the calves for beef production and produce a milk surplus that was sold to produce non-pasteurised artisan cheese (Aranda Ibáñez 2005).

[273] By the time of the fieldwork, INIFAP Tabasco (with the GGAVATT groups) was promoting dual-purpose milk production systems (Valdovinos Terán 2005).

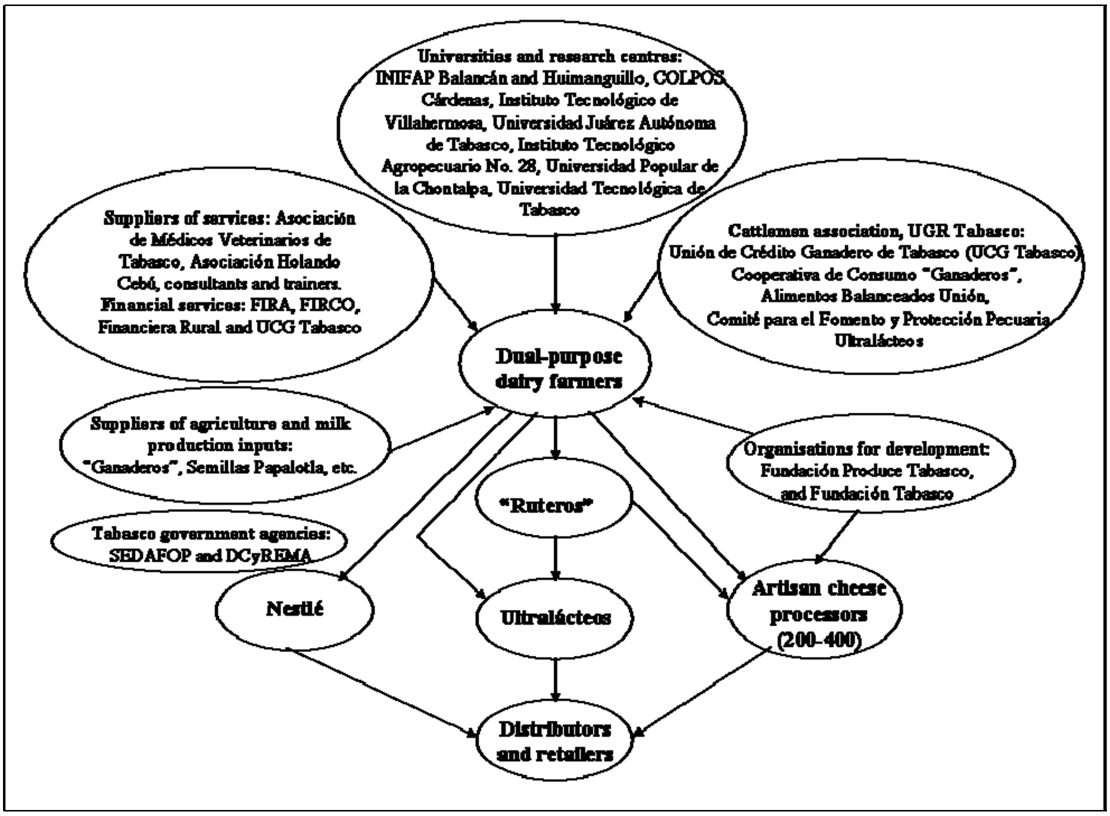
quality of milk and sophisticated dairy products). It took them more than three years after NAFTA was signed to react. At the time of the fieldwork, there were no specific regional policies aimed at facing foreign and national competitors, except the Federal programme PROCAMPO/Alianza para el Campo. Furthermore, some interviewees agreed that many dairy farmers were still unaware of the implications of a total elimination of tariffs at the end of 2008 (Abreu Vela 2005; Caraveo Márquez 2005; Castillo García 2005).

Second, dairy farmers have been affected by the increased introduction of long-life UHT milk by Lala, imported from CONAPROLE Uruguay and distributed in the southern region in 2004 (Caraveo Márquez 2005). Farmers claim that the importers of UHT milk and NFDM do not pay the taxes agreed on to mitigate the effects on local producers. Since taxes were not being effective in maintaining a price floor for milk production, there was a decline in profit margins. Many farmers were unable to invest in technology and to compete, and eventually exited cattle farming. A loss of cash flow and assets has produced dramatic cases of herd and land sales and displacement of farmers with the associated social problems (del Valle Rivera 2000; Alvarez Macías 2005; Caraveo Márquez 2005).

Despite its disruptive impact, NAFTA has also led to the promotion and accelerated introduction of technologies to upgrade agriculture (Caraveo Márquez 2005; Guiot García 2005; Mateos Payro 2005) and dairy production (Díaz Bustamante 2005; Morales Gómez 2005; Ordóñez Vázquez 2005; Pérez Silván 2005) in the region. Many beef cattlemen moved to the dual-purpose systems as an alternative strategy, because milk production provides some liquidity for the operation of the beef cattle production (Abreu Vela 2005; Aranda Ibáñez 2005). Others were able also to introduce grains as feedstock to achieve the beef quality demanded by export markets and some managed to export beef to Korea during the BSE crisis in the US, from 1996 to 2003 (Muñoz Rodríguez, García Muñiz et al. 2003; Luna López 2005). However, the Tabasco dairy system is still undergoing a slow modernisation process focused on improving dual-purpose systems, introducing some technological components of the Holstein model (Muñoz Rodríguez, García Muñiz et al. 2003) and still struggles to maintain a sustainable milk and dairy production system.

5.3.2 Structure of the Tabasco dairy system and actors' role in the evolution of capabilities

The Tabasco dairy system of innovation described here is relatively straightforward at the dairy, similar in complexity to the La Laguna system. However, it is more complex due to the large number of milk producers and artisan cheese processors. The two large dairy processors, i.e. Ultralácteos and Nestlé, have integrated numerous dairy farmers, who increasingly are producing chilled milk, and between 200-400 artisan cheese processors, which have integrated the small dairy farmers, producing non-chilled milk, 'ruteros' help the integration, and some still collect non-chilled milk. Several other private and public organisations (see Figure 5.3) have influenced this integration and the development of capabilities, which are described below and assessed in subsection 5.3.3.



Source: Author's elaboration.

Figure 5.3 Tabasco dairy system of innovation

a) Evolution of capabilities of the networks of dairy farmers in Tabasco

By 2000, milk was being produced in all 17 municipalities of Tabasco, but eight of them accounted for 80% of total output from just 36% of the herd (Muñoz Rodríguez, García Muñiz et al. 2003). These disparities between share of milk production and herd size are a feature of the dual-purpose system, where some dairy cattle are used to feed calves for beef production rather than being milked for industrial purposes.

The population of Tabasco dairy farmers is estimated at 6,200 small stakeholders (approximately 27% of the total of cattle farmers)[274] operating at differential technological levels and constituting a heterogeneous socio-economic group which makes it very difficult to classify and to standardise its operations (SEDAFOP 2004). However, they have increasingly introduced some components of the intensive model including artificial insemination to improve herd genetics, automating milking and chilling tanks and increasingly some agricultural practices to improve feedstock quality with the influence of dairy processors, i.e. Nestlé and Ultralácteos, and other regional actors, since the middle of the 1980s (Muñoz Rodríguez, García Muñiz et al. 2003). Some of their capabilities and development mechanisms are presented in Table 5.20.

[274] Cattle farmers were estimated at 22,000 and make up part of the large rural population which amounted to approximately 46% of the economic population of Tabasco in 2004 (SEDAFOP 2004).

Table 5.20 Tabasco capabilities for milk production and development mechanisms

Capabilities	Development mechanisms
Technological capabilities to improve the genetics of the herd	Increasing use of artificial insemination using specialised semen to improve the genetics of the herd, 98% of the herd are crossbreed animals[275] and there is evidence of some heterosis[276]
Technological capabilities to improve agricultural practices and herd management	99.8% of improved grassland with 36% of grasslands with the native species of the Paspalum grass and the other 64% have new species of grasses[277] 66% of dairy farmers provide supplement (i.e. mineral salts, feedstock and molasses) Increasing use of specialised labour in dairy farms and technical assistance to farmers by Ultralácteos and Nestlé A few exceptional cases of milking twice per day Increase in the scale of production, i.e. number of dairy cows compared to beef herds (92 dairy vs. 64 beef)
Technological capabilities to improve milking systems and hygiene practices	Increasing use of mechanical milking and chilling systems, 10-20% 70-80% of Ultralácteos dairy farmers chill milk and 100% of Nestlé' suppliers
Organisational capabilities to integrate farmers to chill milk and commercialise it for industrialisation	Setting up of the chilling infrastructure supported by Nestlé and Ultralácteos and some resources of other regional actors

Source: Author's elaboration of data drawn from Caraveo Marquez (2005); Guiot García (2005); Morales Gómez (2005); Moreno Ramírez (2005); Muñoz Rodríguez, García Muñiz et al. (2003); Ordoñez Vázquez (2005) and Pérez Silván (2005).

However, overall productivity of the herd in Tabasco is still lower than in other grazing-based dairy systems (see Table 5.21) and is highly variable within Tabasco. It is possible to find cows yielding between 1.5 and 10 litres per day per cow on the same farm. Also, exceptional milk cows producing 21 litres per day can be found (Mateos Payro 2005).[278]

Table 5.21 Comparison of milk productivity per cow in countries with grazing-based milk systems

Parameters (average)	Argentina	Uruguay	New Zealand	Mexico (Tabasco)
Litres per day per cow	17.5	13.2	12.7	4.12
Litres per lactation	5,147.0	3,939.5	3,373.0	878.0
Litres per ha per year	4,795.0	3,100.5	8,770.0	356.0

Source: From Muñoz Rodríguez, García Muñiz et al. 2003, p 30.

[275] The herd is not genetically homogenous and the practices of AI and embryo transplantation are not well-diffused (Castillo García 2005).
[276] Heterosis or hybrid vigour is the increase in such characteristics as size, growth rate, fertility, and yield of a hybrid organism over those of its parents. (http://www.britannica.com/search?query=heterosis (February 15, 2007).
[277] The new species of seeds for grassland have been produced and tested in the tropical region (Guiot García 2005).
[278] This suggests that these results might be based on numbers of cows in dairy production while the very low number may be the result of averaging milk production over a population of dairy cows, many of which may be suckling calves or are young heifers.

It has been argued that that Holsteins in the Chontalpa region were the wrong type of cows because of the harsh climatic conditions, requiring the complementary technologies of the intensive model. Furthermore, most of the farmers were associated in ‘ejidos’ and it was (and still is) difficult for them to reach the scale of production (see Table 5.22) and to solve problems with the management of grazing, nutrition and reproduction cycles for such a specialised dairy cow (Aranda Ibáñez 2005).

Table 5.22 Size of the herd by units of production in Tabasco, 2000

Regions	**Municipalities**	**Number of farms**	**Number of animals**		
			Minimum	*Maximum*	*Average*
Centro	Centro	277	2	1,000	53.8
	Jalpa de Méndez	38	2	335	37.1
	Nacajuca	36	3	219	32.8
Chontalpa	Cárdenas	95	5	290	65.4
	Comalcalco	53	5	373	58.2
	Cunduacán	32	7	220	61.7
	Huimanguillo	143	1	910	72.4
	Paraíso	16	3	202	52.5
Pantanos	Centla	97	2	145	24.7
	Jonuta	142	3	280	45.0
	Macuspana	142	3	3,000	79.3
Ríos	Balancán	261	2	600	83.6
	Emiliano Zapata	34	15	538	94.5
	Tenosique	99	2	1005	118.5
Sierra	Jalapa	92	2	780	81.7
	Tacotalpa	123	1	360	32.8
	Teapa	37	15	2,200	207.4
Total (19,813 farms)		1,717 (sample)	1	3,000	67.6

Source: Muñoz Rodríguez, García Muñiz et al. 2003, p 49.

b) Evolution of capabilities of Tabasco dairy processors

Ultralácteos, SA de CV was the first dairy facility to process long-life UHT milk in the tropical region. It was set up in 1987 by the Tabasco cattlemen’s association, Unión Ganadera Regional de Tabasco (UGR Tabasco) (to which it belongs) to commercialise the milk produced by some of its members (Muñoz Rodríguez, García Muñiz et al. 2003).

Ultralácteos changed the structure of the channels of commercialisation of fresh milk to compete with the ‘ruteros’, Nestlé and the traditional artisan cheese processors (del Valle Rivera 2000; Muñoz Rodríguez, García Muñiz et al. 2003). In 1988, the main collector of milk in Tabasco was Nestlé; in 2005, it was Ultralácteos, displacing Nestlé, and collecting 50-60% of the milk production. However, the traditional artisan cheese processors have managed to maintain their participation in milk catchments since 1988, which makes this group of producers very important in the region (see Table 5.23).

Table 5.23 Tabasco milk commercialisation channels of raw fresh milk

Commercialisation channels of raw fresh milk	1988 % of the total production	2002 % of the total production	2005 % of the total production
Ultralácteos	-	54	50 – 60 (34% chilled milk)
Nestlé	45	4	5 – 10 (100% chilled)
Artisan cheese makers	35	31	20 – 30 (non-chilled milk)
Direct to consumers by ‘ruteros’	19	11	5 – 10 (non-chilled milk)

Source: Author’s elaboration of data from Muñoz Rodríguez, García Muñiz et al. (2003); and for 2005, estimations of data from Morales Gómez (2005).

Ultralácteos collects the milk from all the municipalities via: a) direct collection using chilling transport; b) collection from its catchment centres (with chilling tanks) in 10 municipalities; and c) collection from ‘ruteros’ (Moreno Ramírez 2005). The number of Ultralácteos milk suppliers fell by 50% (approximately 1,650) in the period 1990-2005 (Morales Gómez 2005). Despite this, in 1994-2004, the firm increased its share in milk collection from 38% to 64% and total volume increased 188% (see Table S5.11). This suggests increased specialisation among suppliers or an increase in herd productivity, or both. A further indication of specialisation is that 90% of dairy farmers supplied 66% of the non-chilled milk while just 10% of dairy farmers supplied 34% of chilled milk (Morales Gómez 2005). This situation is similar to that faced by Nestlé in 1991 when it was aiming at collecting 100% of chilled milk from its suppliers by 2000 (Muñoz Rodríguez, García Muñiz et al. 2003; Enrigue Loera 2005).

The size of Ultralácteos’ milk suppliers has not changed much since 1990 when 83% were small farmers producing less than 100 litres per day (Muñoz Rodríguez, García Muñiz et al. 2003). Seventy-seven per cent were still supplying at this level in 2004 with approximately one per cent producing more than 1,000 litres per day (Morales Gómez 2005). Average annual production of milk for dairy farmers who chill their milk is five times higher than for those who do not. It is estimated that 10-20% of milk producers use mechanical and chilling systems (Ordóñez Vázquez 2005; Pérez Silván 2005).

To improve the supply of high quality milk, Ultralácteos has a team of veterinarians in its catchment centres to carry out checks.[279] Once accepted, milk is chilled and storage at 4-6°C. This team advises dairy farmers about how to improve milk quality regardless of the productivity of their system, but there are no procedural guides or manuals to teach good practice. Ultralácteos also trains the 'ruteros' to check the quality of milk against its specifications. The result is that 70-80% of Ultralácteos's milk suppliers have achieved what is deemed to be good practice on their farms (Moreno Ramírez 2005) and receive a higher price for their chilled milk since 2001. The firm is catching up with Nestlé, which has had a similar strategy for a number of years (Muñoz Rodríguez, García Muñiz et al. 2003).

Ultralácteos processes approximately 90% of its milk catchments to produce mainly plain and flavoured long-life UHT milk; approximately 7% is used to produce pasteurised milk cheese and 3% to produce other dairy products. The firm has adapted and developed processes to produce pasteurised milk in plastic bottles, seven different types of cheese, flavoured milk, set and drinkable yogurt, butter and dairy formula for DIF Campeche.[280] However, the firm competes in only two product markets; long-life UHT milk and cheese in the southeastern part of the country (see Table 6.4). Although its brand, Unión™, led the market in Tabasco (Muñoz Rodríguez, García Muñiz et al. 2003), it did not have a significant market share in the national market (Euromonitor 2005). The 'grass taste' of the milk is proposed as one of the main barriers to the firm's success in the national market (Moreno Ramírez 2005).

Ultralácteos has no R&D department, but relies on its internal operations and engineering resources to modernise its processes and on the suppliers of equipment for dairy technology (Díaz Bustamante 2005; Morales Gómez 2005). Since 2000, the firm has managed to modernise its dairy facility (i.e. increased chilling, production and packaging capacities) with assistance from dairy equipment suppliers, consultants and attending at technological fairs and exhibitions. It has also developed new dairy products, operations, processes and specifications and developed information systems

[279] Ultralácteos quality milk tests for acidity, alcohol, fat content, density, neutraliser and chloride (for adulteration), reductase and cryoscopic point (Moreno Ramírez 2005).
[280] DIF Campeche is the Desarrollo Integral de la Familia or Family Integrated Development programme, which is the state agency of Campeche responsible for distributing flavoured milk to social programmes for schoolchildren.

since 1994 to improve the logistics of milk collection and distribution. In 2002, the firm began to develop new areas of marketing, operations and engineering recruiting highly qualified and experienced personnel from other large dairy firms (i.e. Nestlé) and foreign consultancy firms (Díaz Bustamante 2005; Ordóñez Vázquez 2005).

The firm has not systematically trained its employees, except in certain technologies. Nor had it been involved in public support schemes for fostering innovation until 2004 when it began modernisation of its chilling systems for milk collection and improved its dairy production facilities (de la Peña Marshall 2005; Romero Villanueva 2005). The firm has no research projects with universities or research institutions, but has taken students for on site short training periods (Morales Gómez 2005).

Ultralácteos is considered a dairy technology follower of Lala and Alpura; and is lagging behind in the operations and marketing developments (Díaz Bustamante 2005; Morales Gómez 2005; Pérez Silván 2005). Its main contribution to the region is its important social role of integrating dairy farmers (Abreu Vela 2005; Caraveo Márquez 2005; de la Peña Marshall 2005; Gurza Merino 2005; Pérez Silván 2005).

The main achievements of Ultralácteos lie in the increased collection of good quality milk and the development of new dairy products. Nonetheless, the processing of 90% of milk received from dairy farmers using UHT pasteurisation is in marked contrast to the practice of the larger dairy firms in the other two regions. One explanation is that the market demands this type of product. The capabilities developed and mechanisms for building them are summarised in Table 5.24.

Table 5.24 Ultralácteos capabilities and development mechanisms

Capabilities	Development mechanisms
Operational capabilities to improve hygiene practices of milk suppliers R&D capabilities to develop new dairy products, processes and their standards (i.e. pasteurised milk in plastic containers, flavoured milk, set and drinkable yogurt, cheeses, butter and dairy formula)	Developing infrastructure to provide assistance to milk producers and to create a network of milk suppliers of chilled milk Developing milk quality assurance procedures for milk acquisition In-house technical training and joint projects with external suppliers of services, machinery and equipment and food ingredients and quality control processes, engineering, equipment maintenance, quality assurance and information systems Developing procedures for new projects development and post-project assessment and documentation

Sources: Author's elaboration of information from Díaz Bustamante (2005); Morales Gómez (2005); Moreno Ramírez (2005): Pérez Silván (2005); Ordóñez Vázquez (2005).

The second most important firm in the region is *Nestlé.* Although it does not have dairy facilities in the state, it started collecting fresh milk in 1969, which makes it the oldest collector of milk in Tabasco. As in Los Altos, Nestlé has developed networks of small dairy farmers, to supply milk to its milk drying facilities in Veracruz and Chiapas. In 1988, the firm collected approximately 45% of Tabasco milk production (see Table 5.23) from approximately 2,000 dairy farmers (Muñoz Rodríguez, García Muñiz et al. 2003). In 1991, approximately 35% of the milk was chilled using collective chilling tanks; and by 2000, farmers with production of between 300 and 4,000 litres per day had individual tanks and Nestlé achieved 100% of chilled milk collection (Enrigue Loera 2005; Ordóñez Vázquez 2005), which is a great achievement for the tropical region (Muñoz Rodríguez, García Muñiz et al. 2003).

Nestlé has significantly reduced the number of its suppliers in the tropical regions (Muñoz Rodríguez, García Muñiz et al. 2003; Godínez Vázquez 2005) and its share in milk collection has also diminished following the arrival of Ultralácteos. Nevertheless, it collects twice as much as it did in 1994 (Enrigue Loera 2005), with strategies similar to the ones in Los Altos (e.g. premium price for chilled milk, technical and financial assistance to improve the management of the grazing and prairies).[281]

Nestlé also played an important role in the development of herd genetics for dual-purpose systems (Muñoz Rodríguez, García Muñiz et al. 2003; Castañeda Martínez 2005; Enrigue Loera 2005) (i.e. the development of studs and semen of ¾ and 5/8 European-Zebu crossbreeds) for Tabasco and for the tropical regions in general (Castañeda Martínez 2005; Enrigue Loera 2005; Valdovinos Terán 2005) (see Appendix 1, section 2.1 for further explanation of the role of Nestlé in the MDS). The use of the crossbreed together with improvements in farm management have contributed to improving milk yields from an average of 700 litres per year to 2,800 to 3,000 litres per year in some herds (Aranda Ibáñez 2005; Moreno Ramírez 2005).

Another important group of dairy processing is the *artisan cheese producers.* According to Muñoz Rodríguez, García Muñiz et al. (2003), they constitute the oldest family-

[281] Nestlé has closed several facilities in Latin America because of the high costs of milk production. However, it hopes to get cheaper supplies from the Mexican tropical region estimated at $0.30 for its processing plants in Veracruz and Chiapas states (Godínez Vázquez 2005).

owned dairy industry, which started ‘formally’ in the 1930s. This group of some 200 small firms produces cheese on a regular basis, but their number can double during the high milk production season (i.e. June to September). The participation of these firms in the catchments’ of non-chilled milk, has increased from 19% at the end of 1990 to 31% in 2003. They produce regional cheeses, which have soft and slightly matured curds, such as Oaxaca type, ‘Panela’, ‘Asadero’, double cream or Tabasco cheese and ‘de Poro’ cheese[282] (Villegas de Gante 2003). They are sold mainly in local and regional markets but some reach the main urban markets (e.g. Puebla and Mexico City).

Tabasco artisan cheese production is considered of a low technological level for several reasons. First, all production is from non-pasteurised milk because of the incomplete network of chilling tanks and the lack of pasteurising facilities. Second, the cheese facilities lag behind the national leaders (e.g. Chilchota, Sigma Alimentos, Lala and Alpura) with a high diversity of local technologies. Third, the firms do not have standards for products, processes or operations. Therefore, there is high variability in the quality of the final products (i.e. chemical composition, bacteria content, etc.). Nevertheless, it has incorporated endogenous knowledge based on the experience of producers (Muñoz Rodríguez, García Muñiz et al. 2003) and is creating a network of small producers which is expanding in the tropical region and in Central and South America supported by international organisations (i.e. Programa de Fomento Lechero Tropical, i.e. PROFELET[283]). This industry processes approximately 20 to 30% of the total of milk production of Tabasco.

In 2002, *Fundación Tabasco* set up a project to coordinate the efforts of a few groups of artisan cheese producers to develop a cluster (i.e. Association of producers of ‘de Poro’ cheese in the Balancán municipality) to improve infrastructure and economic capacity to commercialise their products through larger retail channels, including the development of a PDO for ‘de Poro’ cheese, for which they worked together with CIATEJ (Ceballos Falcón 2005; de la Peña Marshall 2005).

[282] ‘de Poro’ cheese is produced mainly in the municipalities of Balancán and Tenosique.
[283] PROFELET is part of the GERSSE inter-state long-term project (see Fundación Tabasco).

c) Role of the network of suppliers of inputs and services in improving capabilities

The Tabasco dairy system has a simple structure of suppliers of inputs for milk production, which is mainly organised by the Tabasco cattlemen's organisation, *Unión Ganadera Regional de Tabasco*, *UGR Tabasco*, which has been one of the most influential political associations of cattle farmers in Mexico (Piedra Ibarra and Ramos 2005).

UGR Tabasco was set up in 1936 to support the development of beef cattle and participated in the Chontalpa plan project and from 1986 to 1992 trained cattlemen to improve milk production (Aranda Ibáñez 2005). By 2005, approximately 70% of the cattlemen of the state were members (Pérez Silván 2005). It has created a network of cattle services, which in addition to Ultralácteos commercialising milk, includes the largest network of cattle inputs suppliers in the south of Mexico (i.e. Cooperativa de Consumo 'Ganaderos'), which has made attempts to develop local technologies and suppliers of these technologies (e.g. small milking machines and chilling systems for small farmers) (Caraveo Márquez 2005), a credit union (UCG Tabasco), a slaughterhouse and beef packing facility, an animal transportation firm and a feed production facility. It also has a joint programme with SEDAFOP[284] to campaign for animal health protection in Tabasco and to improve the genetics of the herd (i.e. Comité para el Fomento y Protección Pecuaria del Estado de Tabasco, S.C., CFPPET)[285] (see Table S5.12). Despite all its efforts, UGR Tabasco has had to receive funding from the Federal and Tabasco state governments to set up its infrastructure and to operate because it has experienced recurrent financial problems (Hernández 2007).

To support the development of intensive grazing systems, *Semillas Papalotla* (a private producer of seeds for grazing) has operated in Tabasco since 1998, and has introduced new varieties of grasses, leading to increased grazing densities. To achieve this, the firm worked with INIFAP Tabasco and COLPOS Cárdenas to test the productivity and digestibility of the grasses and with Nestlé on the commercialisation of the new seeds (Aranda Ibáñez 2005; Guiot García 2005). It has been argued that these new varieties

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[284] SEDAFOP is the Tabasco state office of SAGARPA, i.e. Secretaria de Desarrollo Agropecuario, Forestal y Pesquero.

[285] CFPPET has been working successfully with SAGARPA and SEDAFOP since 2000 to eradicate tuberculosis and brucellosis and has offered training courses, together with the UGR Tabasco, in the areas of animal reproduction and artificial insemination for more than 40 years (Castillo García 2005).

might change the ecology of the region generating further environmental problems (Hernández Laos and del Valle Rivera 2000).

d) Role of the network of financial suppliers in improving capabilities

The funding from financial organisations has been less important than in other regions for milk production. FIRA, in association with UCG Tabasco, have financed mainly beef cattlemen (Luna López 2005). FIRCO and Financiera Rural provide economic resources from the Alianza para el Campo to improve agricultural practices and to create some infrastructure for chilling milk (Caraveo Márquez 2005). However, there have been no major dairy development projects, apart from those initiated by Fundación Produce Tabasco (see below in *f*).

e) Role of the universities and the regional research centres in improving capabilities

The Tabasco dairy region has a network of some nine colleges and universities, which offer undergraduate, masters and research programmes in veterinary science, agriculture and food technology (see Table S5.13). Some of them offer training courses to farmers in collaboration with Ultralácteos, Fundación Produce Tabasco, and the UGR Tabasco. However, one of the main problems is integration of the different programmes (Castillo García 2005; Martín Ruíz 2005; Moreno Ramírez 2005).

Many of these programmes have not been updated to meet the demands of users in terms of providing the education required to improve the competitiveness of the dairy region (Abreu Vela 2005; de la Peña Marshall 2005; Fernández Fernández 2005; Romero Villanueva 2005). Some exceptions are COLPOS Cárdenas and INIFAP Tabasco.

COLPOS Cárdenas[286] has a master's programme specialising in agribusiness for the commercialisation of regional products and environmental conservation. It also offers a PhD programme in animal production and dual-purpose systems addressing local needs of farmers.[287] It produces technical bulletins, videos and runs technology transfer

[286] COLPOS Cárdenas is the postgraduate research unit in the tropical region of UACh (see SNIA Section 2.2 and Appendix I Section 1.2).

[287] According to Aranda Ibañez (2005), the areas of research include improving cow fertility rates, improving practices for raising calves and heifers, improving animal nutrition using endogenous forage

workshops. The main constraints to R&D projects are lack of resources and the problems involved in reaching the farmers, who are numerous and dispersed across the state (Aranda Ibáñez 2005).

INIFAP Tabasco's [288] research focus is on development of intensive grazing systems. It produces technical publications[289] but they are not widely circulated (Abreu Vela 2005; Gurza Merino 2005). In addition to research, INIFAP Tabasco introduced GGAVATT groups in cooperation with Tabasco government organisations, SEDAFOP and DCyREMA (see below in *f*) in the mid-1990s, which have had some success at improving agricultural technologies and codifying farm activities. Some of these successful groups are APROLAC[290] and Gavateros de Comancalco. They are currently commercialising chilled milk for cheese producers in the Estado de Mexico (Ramírez 2006). However, adoption of the GGAVATT model has been slow. One of the problems is that the model has not been updated and it does not cover commercialisation and dairy processing practices (Abreu Vela 2005; de la Peña Marshall 2005; Fernández Fernández 2005) .

One problem in technology transfer is that universities and the INIFAP rewards system, SNIA, does not value the linkages between users and producers. Therefore, the diffusion of knowledge is limited (Aranda Ibáñez 2005) (see Appendix I, section 1.2 for the problems in the reward system of the SNIA).

f) Role of the organisations for regional development

Tabasco has only a few development organisations that have initiated some dairy development projects. For instance, *SEDAFOP* has had a dairy development programme in the tropical areas since 2000 (i.e. PROFELET) with resources from

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such as sugar cane and native plants (e.g. 'cocoite'), developing sustainable sugar cane and cattle production, drought management and developing Chontalpa projects on sheep, citrus and bananas.

[288] INIFAP Tabasco research unit has two research stations at Balancán and Huimanguillo municipalities. They are part of the Research Regional Gulf Centre (i.e. Centro de Investigacion Regional Golfo Centro, CIRGOC), which is responsible for research in the tropical states of Veracruz and Tabasco.

[289] For example, the technical publications of SAGARPA-INIFAP: Manejo de ganado bovino de doble propósito. Libro Técnico Núm. 5 (Octubre 2002); and Tecnología para la producción y manejo de forrajes tropicales en México. Libro Técnico Núm. 7 (Noviembre 1999).

[290] APROLAC originated from APROS, which was an association of dairy farmers in Macuspana municipality in 1981and became a dairy cooperative in 1994. It established APROLAC, AC in 1999 and became a dairy firm, APROLAC Macuspana, SA de CV in 2005. It has 280 partners, 63 dairy farmer associations with approximately 1,200 dairy farmers. It is a successful organisation of dairy farmers (de la Peña Marshall 2005, Mateos Payro 2005, Muñoz Rodríguez, García Muñiz, et al. 2003).

Alianza para el Campo, which focuses on: a) the re-population of dual-purpose herds; b) the development of prairies for intensive grazing; and c) the establishment of milking machines and chilling tanks on farms, under the Tabasco Development Plan 2002-2006 (Mateos Payro 2005).

SEDAFOP has also coordinated the DEPAI and GGAVATT groups and, since 2002, its unit for the training of livestock farmers (and fisherman) (i.e. Dirección de Capacitación y de Reproducción de Especies Menores y Acuícolas, i.e. DCyREMA)[291] and FIRA (see Appendix I, section 1.3) have provided customised 'on site' training courses. The training programme is designed according to the needs of the farmers "tailor-made programmes". SEDAFOP members assess the needs of the farmers through local associations from October to December of the year before they are to be delivered. These needs are "translated" into training courses by DCyREMA and its training centre CECAREM (i.e. Centro de Capacitación y Reproducción de Especies Menores). CECAREM looks for the trainers and assesses which capabilities to develop, implement and follow up the results of the training courses. Trainers are in charge of "linking farmers with the programme". CECAREM has assessed the training courses yearly, but one year is a short time to note results. Many times, changes take longer to be noticed. For instance, implementation of a cooling system on a farm takes the development of a small project, the acquisition of the resources, the start up of the project and the adoption of the technology and the assessment. However, DCyREMA claims that these training programmes have contributed to improving the profitability of cattlemen by 10-20% in 3 years for a reduced number of farmers (3-4% of the whole population) (SEDAFOP 2003; SEDAFOP 2004; Abreu Vela 2005) (see also Table S5.14). However, the assessment of the training programmes has been criticised as being inadequate to fully assess capabilities building[292] (Abreu Vela 2005; Alvarez Macías 2005).

It has also been argued that due to those changes in milk production practices, milk production is not a subsistence activity anymore and is becoming an industrial activity in the region (Alvarez Macías 2005; Mateos Payro 2005; Pérez Silván 2005). However,

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[291] Among all Mexico's states, Tabasco is dedicating the highest budget to agriculture. It started with Pesos 89 million in 2002, which had increased to Pesos 100 million by 2005 (Abreu Vela 2005).

[292] DCyREMA since 1998 has assessed its training courses annually using the SAGARPA-FAO methodology. However, DCyREMA is conscious of the limited results after only a short period of adoption of technology for the assessment (Abreu Vela 2005).

the restricted amount of economic resources for the large population of farmers in the region has left them behind in the development of capabilities. Moreover, most of the resources and training programmes have been provided mainly to large farmers in the region, who have the power to lobby the government agencies (Alvarez Macías 2005; del Valle Rivera 2005; Mateos Payro 2005).

Since 2002, *Fundación Tabasco,* a civil organisation of Tabasco's entrepreneurs and SEDAFOP, set up the 'Tabasco en Acción' programme to develop strategic sectors, of which one of them is milk and dairy production. For the project of milk and dairy production, *Fundación Tabasco* is promoting an ambitious portfolio of ten long-term projects[293] aimed at improving the competitiveness of artisan cheese production with the development of a dairy cluster in the tropical region by 2025 under the GERSSE project[294] (Fernández Fernández 2005; Romero Villanueva 2005). It is also in charge of following up on the use of resources invested by the Secretary of Economy (i.e. Fondos PYME[295]) in Ultralácteos, Gavateros de Comalcalco and other agriculture producers (Fernández Fernández 2005). Its main contributions in the development of the dairy cluster project are as follows (Ceballos Falcón 2005):

a) identification of opportunities for dairy projects, the diagnostic phase for PROFELET;
b) development of a dairy network of milk producers aimed at rural sustainability;

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[293] The main projects are: a) organisation of cattlemen with the systematic development of 17 municipality dairy councils; b) creation of a network of dairy development; c) training of cattlemen in the production of milk; d) development of three regional training programmes for dairy producers including their own suppliers; e) training programme for technicians in tropical dairying, which includes diplomas in dairy production and maintenances of dairy equipment; f) development of a strategy to add value to milk and dairy products; g) export programme for regional cheese to the US and development of the national cheese market; h) development of an infrastructure to dehydrate milk; j) development of infrastructure for a laboratory for the controlled production of milk; and k) development of an applied research institute for dairy processing and commercialisation (Ceballos Falcón 2005, de la Peña Marshall 2005).

[294] This is a long-term inter–state' government project aimed at exploiting the comparative advantage of the tropical region for the production of milk and dairy products, headed by the Economic Group of the South and South-Eastern Region (Grupo Económico de la Región Sur-Sureste, GERSSE). In 2005, the main dairy projects carried out by the organisation included technical support for the introduction of technology in artisan cheese production in the municipalities of Huimanguillo, Jalapa and Comalcalco; integration of the value chain of artisan cheese processors aiming to develop animal health and industrial standards for the production of safe dairy products; the development of a dairy basin to integrate Tabasco, the south of Veracruz, Campeche, Oaxaca, and Quintana Roo and the northern parts of Chiapas and Guatemala (Fernández Fernández 2005).

[295] Fondos PYME are Federal resources for funding the development of medium and small enterprises.

c) development of a PDO for 'de Poro' cheese, for the Balancán municipality in collaboration with CIATEJ (see Los Altos case);

d) development of a network for exchanging experience with other dairy farmers[296] (Fundación Tabasco 2006).

Fundación Produce Tabasco is another developmental non-profit organisation of Tabasco farmers and SEDAFOP officers set up in 1996 to influence decision-making in the agricultural sector (see Appendix I, section 1.2). The organisation aims at meeting the research demands for agriculture, cattle, forestry, and fisheries. It was responsible for allocating resources to carry out projects with INIFAP Tabasco until 2002.[297] Since then, new procedures and a research committee to identify the needs of the users (i.e. farmers) have been introduced together with a more transparent allocation of resources (Gurza Merino 2005). Some of the main activities carried out by Fundación Produce Tabasco in the development of dairy systems are[298]:

1. supporting research projects in animal nutrition using intensive grazing and mineral supplementation;
2. developing workshops with Ultralácteos in ten milk-collecting centres to train dairy farmers to improve milk quality;
3. delivering training courses for intensive grazing and herd management with cattlemen associations;
4. organising cattlemen groups, e.g. APROLAC;
5. supporting dairy technologies development to produce safe dairy products using pasteurised milk;

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[296] Exchanging experience with 'Cotija' cheese producers in the region of Sierra Jalmich (Jalisco and Michoacán state borders), Querétaro and Chiapas. Fundación Tabasco is collaborating on milk production with a dairy NGO in Peru (i.e. ADRA Peru) (Ceballos Falcón 2005; Chombo Morales 2005; de la Peña Marshall 2005).

[297] For instance, until 2001, 50% of the resources for research were allocated to INIFAP Tabasco without any assessment of its results. Most of the projects have not attracted users. The current procedure starts with the identification of the demand of research projects detected by SEDAFOP officers and UGR Tabasco following the concept of the CSPBL. Researchers from the Fundación Produce Tabasco Committee 'translate' the demand of farmers and cattlemen to projects and call research institutions (e.g. INIFAP Tabasco and COLPOS Cárdenas) and consultants for research proposals. The Committee assesses the research proposals under specific criteria and eventually allocates the financial resources to carry out the projects (Gurza Merino 2005).

[298] For more details of the projects related to cattle, see Fundación Produce Tabasco website: http://www.fuprotab.org/secciones/proyectos.html (December 20, 2005).

6. supporting the development of a new dairy facility to produce pasteurised organic milk;
7. supporting the development of technical manuals on herd management, mastitis control, animal reproduction, milk production, etc.;
8. supporting the development of the biennial international forum on the tropical dairy (i.e. 'Foro Regional de Lechería Tropical') since 2000.

However, technology transfer activities in the region are limited (Abreu Vela 2005; Fernández Fernández 2005; Gurza Merino 2005), the main mechanism continuing to be face-to-face sharing experience and endogenous knowledge among cattlemen from technology farmer leaders (Castillo García 2005; Martín Ruíz 2005; Moreno Ramírez 2005).

5.3.3 Functions and dysfunctions of the Tabasco dairy system: assessing the role of the actors involved in capabilities building

The structure of the Tabasco dairy region is composed of two large firms, Ultralácteos and Nestlé, which integrate a large number of milk producers with heterogeneous technologies and a large group of farmers that also produce artisan cheese with low technological capacity. The complexity of the system in this region is due to the variety of farmers engaged in dual production and the large number of artisan cheese producers.

Ultralácteos and Nestlé have assisted farmers to change their routines into improved capabilities together with other regional actors, which have supported the technology transfer and learning mechanisms. Some of these mechanisms are the training programmes provided by DCyREMA, CFPPET, Fundación Produce Tabasco, and UGR Tabasco together with Ultralácteos and Nestlé. There has been technical assistance from suppliers of agriculture and dairy production, implementation of technology transfer from INIFAP to farmers, DEPAI and GGAVATT groups, and the biennial international dairy forum for tropical regions (i.e. 'Foro Regional de Lechería Tropical').

Based on the prior discussion, it can be said that the Tabasco dairy system has developed and accumulated the capabilities shown in Table 5.25.

Table 5.25 The Tabasco dairy system capabilities development for milk production and commercialisation

Technological capabilities	Organisational capabilities
Developing procedures and routines for cow's reproduction (e.g. heat detection and artificial insemination), technologies for intensive grazing systems and regional agricultural technologies for grain, alternative forage and silage production to decrease the seasonality of milk production Developing the infrastructure to improve the quality of milk and to implement some best practices in dairy farming Adapting foreign technologies for dairy farming Developing suppliers of new seeds for intensive grazing systems R&D capabilities to improve cows' genetics for tropical regions	Developing limited networks of suppliers of high quality chilled milk Developing operational capabilities for animal health campaigns for disease eradication Developing tailor-made training programmes for milk production Developing a supply chain for agriculture and dairy inputs Developing technology transfer processes i.e. DEPAI and GGAVATT groups Developing a tropical artisan cheese producers cluster in the region of Balancán Developing specialised university programmes in animal production, nutrition and health and dairy processing

Source: Author's elaboration

In the case of dairy processing, the Tabasco dairy system has developed the capabilities summarised in Table 5.26.

Table 5.26 Tabasco dairy system capabilities for dairy processing

Technological capabilities	Organizational capabilities
Developing new dairy products (i.e. pasteurised milk in plastic bottles, flavoured UHT milk, cheeses and yogurt) and associated processes and specifications Quality control operational systems capabilities	Increasing development of institutions to support the industrial production of a regional cheese production (i.e. 'de Poro' cheese)

Source: Author's elaboration.

Some of the mechanisms of collaborative learning to create these capabilities include: development of internal procedures in Ultralácteos supported by technology suppliers, technical assistance from consultants and CIATEJ for regional cheese production and recruitment of experienced personnel to update and expand Ultralácteos' capabilities.

Although some capabilities have accumulated, the economic results for milk production in the period 1994-2004 show that Tabasco's share of milk production has decreased from 1.23% to 1.01%. This decline is due to the slower growth rate of 0.99%, which is lower than for national milk production, 3.04%. Nevertheless, the growth in the dairy cattle herd in the region was 3.48% higher than the national rate of 3.20% over 1994-2004 (see data in Table 6.1). These figures suggest that the average productivity of the herd has not improved, a result that might reflect the use of some milk output in beef production. However, some of the achievements of the Tabasco dairy system include:

1. increasing modernisation of the dual-purpose systems, which has improved yields, although with high variability among the herds;
2. infrastructure improvements in relation to mechanical milking and chilling milk systems, which have led to development of a network of dairy farmers in high quality chilled milk for Ultralácteos and Nestlé for industrialisation;
3. expansion of the network to supply inputs for cattle (i.e. 'Ganaderos');
4. development of an infrastructure to assess animal health, reproduction and nutrition practices (i.e. laboratories for animal pathology and feedstock bromathology and frozen semen banks) (i.e. UGR Tabasco services);
5. development of new dairy products, related processes and specifications (i.e. Ultralácteos) and improvement of the organisation for artisan cheese production (i.e. 'de Poro' cheese).

Blocking mechanisms and constraints for capabilities building

In addition to climatic constraints, which include floods and require frequent herd relocation to different plots of land, droughts[299] also occur which require further management of the herd, constraints that are specific to the region. The constraints of the Tabasco dairy system are:

1. Short-term vision among actors and lack of trust among them, which are numerous, leading to the decision-making process for pursuing long-term projects often being ineffective because of lack of linkages and institutions (Muñoz Rodríguez, García Muñiz et al. 2003; de la Peña Marshall 2005; Fernández Fernández 2005).
2. Many cattlemen dedicated to economic activities other than milk production which has had impeded specialisation in milk production. Some are PEMEX[300] labourers who have invested in cattle (Mateos Payro 2005) but are not interested in living on the farm or managing a production system.[301]

[299] In early 2005 there was a major drought in Tabasco, which affected milk production.
[300] PEMEX is the largest Mexican oil producer, which pays higher wages than other firms in the region and the country.
[301] The large cattlemen maintain that they do not live on their farms because of the poor communication infrastructure.

3. ‘Paternalism’ syndrome dominating the cattlemen, who forcefully lobby the Federal and Tabasco governments in order to get public resources.[302] This situation does not favour collaboration for innovation.
4. Despite some improvement in the education of cattlemen in the region,[303] the low levels of education of most farmers and their low economic capacity have impeded the modernisation process. There continues to be a belief that implementation of technologies does not offer appropriate or useful solutions (Abreu Vela 2005; Gurza Merino 2005).

Table 5.27 summarises the evidence from the analysis of the collective activities, processes and mechanisms of different actors that contributed to regional capabilities development supporting functions as well as the blocking mechanisms and constraints that have impeded the development of capabilities and led to dysfunctions in Tabasco region.

[302] Interviewees preferred not to be quoted.
[303] First generation did not complete primary school, second generation generally achieved technical schools, and third generation sometimes have university education. These two last generations are the ones that have been most instrumental in changing milk production practices (Abreu Vela 2005; Aranda Ibañez 2005; Gurza Merino 2005).

Table 5.27 Tabasco dairy system's functions and dysfunctions

Functions	Dysfunctions
Creating and diffusing new knowledge	
R&D capabilities for milk production using dual-purpose system, e.g. intensive grazing systems and improving animal genetics (INIFAP Tabasco, COLPOS Cárdenas and Semillas Papalotla) Innovating capabilities for dairy production (Ultralácteos and artisan cheese processors) Technology transfer capabilities (DCyREMA, GGAVATT and DEPAI groups and tropical dairy forum)	Insufficient training to improve human capabilities in numerous farms (e.g. herd management, intensive grazing practices, hygiene practices, etc.) and artisan cheese production aiming to increase the profitability of the units of production
Driving research process	
Organisational capabilities to create institutions to influence research process for milk production and dairy processing, the tropical dairy cluster (Fundación Tabasco, Fundación Produce Tabasco, INIFAP Tabasco and SEDAFOP) Activities of Fundación Tabasco and GERSSE project to support milk production and artisan cheese production	Lack of integrated research programmes for tropical dairy development (e.g. identification of the economic size of dual-purpose systems, assessment of the economic sustainability of the tropical dairy region)
Entrepreneurial experimentation	
Developing suppliers of seeds for tropical grazing (Semillas Papalotla and INIFAP Tabasco and COLPOS Cárdenas)	Lack of incubating activities for associated industries to supply inputs to the dairy sector (e.g. industrial production of crossbred studs and semen, heifers for replacement, milking and chilling systems suitable for small herds)
Facilitating the formation of markets	
Creating a network of dairy suppliers of high quality chilled milk (Ultralácteos, Nestlé and dairy farmers)	Limited integration of small dairy farmers and dairy processors Limited expansion of the markets of Ultralácteos and artisan cheese processors
Creating positive externalities	
Changing research infrastructure to meet the demands of farmers (Fundación Produce Tabasco, Fundación Tabasco and INIFAP Tabasco) Developing institutions for animal disease control (dairy farmers, SEDAFOP, UGR Tabasco and CFPPET) Creating a network of suppliers of inputs for cattle production, i.e. 'Ganaderos'	Lack of research to update technology transfer methods (e.g. GGAVATT and DEPAI groups) Inadequacy of the reward system for researchers of the SNI to diffuse technologies from research organisations Displacement of dairy farmers and creating social problems Lack of institutions to update university education system for agribusiness Inadequacy of the assessment of Alianza para el Campo resources for training Lack of institutions to influence IPR laws, environmental sustainability for the use of new agricultural practices (e.g. introduction of new grasses and intensive grazing systems), safety regulations (e.g. standardisation and best practices in farms) and to assess and mitigate the entry effects of subsidised NFDM and dairy products
Legitimation	
Increasing use of technological components of the Holstein model to improve dual-purpose systems Development of an regional artisan cheese industry (i.e. 'de Poro' cheese) including its PDO (CIATEJ, Fundación Tabasco and artisan cheese producers)	Lack of institutions to create industrial standards for dual-purpose systems, and regional cheese production
Mobilising resources	
Public and private investment for the modernisation of the system (Alianza para el Campo, dairy farmers, Ultralácteos, UCG Tabasco and Nestlé)	Limited economic and institutional support for modernisation of numerous small farmers

Source: Author's elaboration.

5.4 Summary

This chapter has provided evidence of the evolution of capabilities of dairy farmers and processors, which have contributed to functional and dysfunctional performance of the dairy regions as they attempt to adapt to the changes provoked by neo-liberal policies.

5.4.1 The expansion and consolidation of La Laguna dairy system

The modernisation of La Laguna dairy system is based on adoption and adaptation of an intensive milk production system making heavy use of foreign technologies. This process has been complemented by growing endogenous capabilities, which have led to extensive integration of the value chain with high quality chilled milk, profitable large scale of production on farms and in dairy processing that has resulted in highly concentrated industry structure with a high rate of development of new dairy products.

The region has developed a ‘milk culture’ (similar to the ‘cotton culture’ developed up till the 1950s). However, this process has taken more than 50 years[304] and changes cannot be attributed to NAFTA although NAFTA has threatened the profitability of the region.[305]

La Laguna faces some problems that might slow its development or reduce the sustainability of the system in the long term based on overexploitation of its water resources, contamination of the environment and the high costs of milk production (i.e. high cost of forage and electricity, imported agriculture and dairy production inputs including dairy technologies).

The existence of dysfunctions in the system provides some opportunities for regional policy makers (see in Table 5.8 the dysfunctions column), for instance, industrial production of inputs and the services for milk production (e.g. production of heifers and semen), which would benefit not only La Laguna region, but also the whole MDS.

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[304] The period of 50 years is defined by the first pasteurising facility, which was set up in 1950.

[305] García Hernández, Aguilar Valdés et al. (2005) pp 204-223 provide evidence of the accumulated experience of dairy farmers in the region.

5.4.2 The transformation process of Los Altos dairy system

The complex structure of industry actors, e.g. large, medium and small sized farmers using a wide range of technologies have coevolved with other regional organisations to deal with the modernisation process. This process started before NAFTA with the introduction of collective chilling tanks and the organisation of dairy farmers, some of whom have resisted the changes. However, there has been an increasing implementation of the technological components of the specialised system for milk production following NAFTA. The overall result has been rapid growth in milk production, which has attracted new dairy processors to the region, while integration of the value chain has eliminated most of the 'ruteros'.

However, the Los Altos dairy system has some problems that might slow its growth and sustainability in the long term. Most of these problems are the consequences of the increasing cost of the inputs for milk production (see dysfunction in Table 5.19). These might force farmers to achieve scales of production that make the business profitable and to complete integration. However, this strategy has been shown to be problematic because of the lack of collaboration among farmers to form collective endeavours including innovation collaboration or shared infrastructure. To the extent that cooperation is needed, it is threatened by a lack of trust and collaboration among the relevant groups to develop new capabilities either for working in groups or continuing to improve milk practices in small farms.

5.4.3 The struggle in the modernisation of the Tabasco dairy system

The Tabasco dairy system is still far from being modernised which is affecting its ability to compete in the national market (see Table 6.1). Milk production and industrialisation in the tropical regions is complex because of the heterogeneous and numerous groups of dairy farmers and artisan cheese processors. Despite the collective efforts carried out by farmers, Ultralácteos and Nestlé, the average quality of milk is still lower than in the other regions as indicated by the fact that 90% of the milk is processed by UHT pasteurisation (although this is also due to limitations in the distribution system which often lacks refrigeration capabilities). This has restricted the production of diversified dairy products. However, artisan cheese processors have improved their capabilities, which might indicate a change in the pattern of tropical dairy development, in which production of regional cheese might be one way to modernise the system to support the underlying social and political agenda of maintaining farm incomes and slowing the rate of migration to cities or emigration. This might require further participation of public organisations (e.g. the Secretariats of Health and Economy), to develop and enforce laws, norms and standards for the production of safe dairy products. However, it is not clear what the actors in the system want to achieve, since the system has a dual-purpose technology for milk and beef production. Nor is it obvious whether milk production is a good alternative (although it has grown at a faster rate than beef production) (see Figure 6.1), or whether it is just a by-product of beef production.

This chapter has provided evidence of the processes carried out by the various actors in the dairy regions to develop regional capabilities. Whereas La Laguna and Los Altos have developed faster than Tabasco, it is not clear whether their capabilities will sustain the economic growth of the regions.

The cross-case analysis on Chapter 6 provides a contrasting insight into capabilities development that contributed to functions and dysfunctions in the dairy regions. This analysis is the bases for the policy making to improve capabilities development to support the development of the regions discussed in Chapters 6 and 7.

Chapter 6. Cross-case analysis of capabilities evolution in dairy regions and implications for policy making

The modernisation of the Mexican dairy regions has been an uneven process with substantial differences in the growth of regional capabilities. This chapter systematically compares the functions (accumulation of clustered capabilities) and dysfunctions (lack or underdeveloped capabilities) in the regional dairy systems examined in this research in Chapter 5, during the period following NAFTA. This comparison leads to specific policy recommendations that aim to support economic sustainability of the dairy regions.

In this chapter, section 6.1 compares the changes in structure of the three dairy regions, highlighting commonalities and identifying their main structural differences, which supported or failed to support capabilities evolution. Section 6.2 compares the economic performance of these regions in terms of milk and dairy production achievements associated with the changes in capabilities of the regions and some implications for the overall performance of the regions. Section 6.3 examines the intra and inter organisational capabilities formation in each of the dairy regions based on the summaries provided in each of the cases (Tables 5.6 and 5.7 for the La Laguna region, Tables 5.17 and 5.18 for the Los Altos region and Tables 5.25 and 5.26 for the Tabasco region). Section 6.4 identifies how intra and inter organisational capabilities contributed to each of the functions using the analytical framework (see section 4.2). Based on the evolution of capabilities from the analysis of functions and dysfunctions, section 6.5 elaborates a set of policy recommendations to develop regional capabilities to support the growth of milk and dairy production for economic sustainability of the dairy regions. Finally, section 6.6 summarises the chapter.

6.1 Cross-case analysis of the changes in the structure of the dairy regions in terms of actors, networks and institutions

The main similarity in the evolution of the regional capabilities in the dairy regions is that they follow the modernisation of the milk production systems based on the implementation of sets of practices of the intensive model. Dairy farmers with different systems of production increasingly have integrated and implemented specific technological components and practices to produce milk, which involved similar technologies, procedures, artefacts and processes. In practice, technological convergence appears to be underway. However, the results overall show different levels in the introduction of technologies and good farming practices, ways of preserving milk quality (i.e. the use of chilling tanks) and the organisation of milk collection, which lead to increased production and commercialisation of better quality milk.

In all the regions, the dairy firms have led this type of modernisation for dairy farming by demanding increasing amounts of high quality chilled milk. Furthermore, the integration of the dairy farmers in all the regions followed similar strategies; dairy firms provided technical assistance and financial credits to support adoption of modernised practices. Well-developed networks of national and MNC suppliers of inputs have also contributed to this process along with other development organisations, including government agencies, which have supported the development and improvement of certain practices for agriculture and dairy farming.

The increasing quantity and improved quality of chilled milk supported the modernisation of dairy processing, which has resulted in production of better and more varied dairy products, following international trends in dairy production. Dairy firms' strategies have relied on their own R&D efforts either in alliances with foreign firms (i.e. Lala and Sigma Alimentos) and/or by relying on MNCs and national suppliers of food and dairy technologies (i.e. Lechera Guadalajara, Alimentos La Concordia and Ultralácteos), or both. However, it is not clear whether the capabilities created will lead to economic sustainability of the dairy regions in the long term with further unexpected or negative consequences such as the increasing displacement of dairy farmers and environmental changes (e.g. exhaustion of water and erosion of land).

The most important difference in the changes of the structures of the dairy regions, i.e. actors, institutions and networks (following Bergek, Jacobsson et al. 2008), is that La Laguna has a straightforward structure constituted mainly by fewer larger and medium-sized farmers with more homogeneous technologies and practices for milk production and with the largest infrastructure to chill and collect milk for industrialisation and two main dairy firms, compared with Los Altos and Tabasco (see Table 6.2), which have more complex structures. This appears to explain the differences in the evolution of capabilities in the regions in three main ways:

a) The integration and coordination of a large number of small farmers in Tabasco (approximately 6,200) and Los Altos (approximately 16,000) into the value chain is still an evolving process because of the inadequacy of the programmes to support capabilities development of a large number of small farmers. As a result, many of these farmers have not been able to change their practices and improve their capabilities and still have low productivity on their farms and produce heterogeneous quality milk. Nor do they have chilling systems to commercialise chilled milk. Therefore, artisan cheese processing constitutes an alternative industry in Los Altos and certainly in Tabasco, which absorbs a significant part of the milk output.
b) Coordination of the learning processes is centralised in a few organisations in La Laguna and decentralised in many organisations in Los Altos and Tabasco,[306] which might impose some problems for their alignment of aims and effectiveness in their collective activities. For instance, the training programmes carried out by government organisations and multiple suppliers of inputs for dairy production have not been sufficient to develop the capabilities of a large number of small farmers in Tabasco and Los Altos (e.g. DCyREMA and national ‘methods’ for technology transfer GGAVATT and DEPAI) compared with La Laguna. In this region, additionally to the fact that Lala is ‘orchestrating’ the integration of a large number of farmers, (some of whom are also Lala shareholders), facilitates the establishment of standards for milk and logistics for its commercialisation. Furthermore, many large farmers have the resources and presumably better absorptive capacities and have developed networks for learning (e.g. PIAL project, ENGALEC, ITESM training programmes) together with other organisations (i.e. suppliers of inputs for milk production) in which they are also part (i.e. UGR La Laguna). As a result, they have improved substantially the overall level of dairy farming capabilities for milk production in the region.

[306] Large firms play the role of systems integrators to stir up the learning processes (von Tunzelmann 2009a, p 22).

c) Government organisations (i.e. states' Fundaciones Produce, INIFAP regional offices, FIRA, FIRCO and Financiera Rural regional offices) have not been able to provide sufficient resources to fully upgrade the technological infrastructure mainly for small farmers in all the regions. These upgrades are particularly needed to improve capabilities in Tabasco and Los Altos (e.g. development of the herd genetics and introduction of milking machines and chilling systems regions-wide). As a result, the productivity of cows and integration of the value chains were lower than in La Laguna.

The main institutions emerging (and possibly co-evolving) in the regions that have helped the capabilities building are:

a) the market of high quality chilled milk for industrialisation is well-established in La Laguna (98%) and still evolving in Los Altos (80-90%) and Tabasco (60-70%). These results were the collective efforts of large regional firms, supporting organisations and government agencies, which have worked together to improve the capabilities on individual farms and develop infrastructures to secure quality and volume of milk for dairy production;
b) the public and private institutional set-ups that provided the resources to build up the dairy infrastructure through different organisations and programmes (e.g. PROCAMPO/Alianza para el Campo, FIRA, UCIALSA, and CONACYT). However, they operated from different economic and organisational bases, and have mainly favoured large dairy farmers and firms;
c) progress has been made in the regional standardisation of the dairy industry (e.g. some dairy firms have been certified by COFOCALEC in Jalisco). However, there is uneven development and compliance with regional and nationwide standards in the dairy industry, because of a lack of infrastructure to develop and enforce them.

Regarding learning networks, the ones established in La Laguna were simpler than in Los Altos and Tabasco. In La Laguna, PIAL projects with ENGALEC and INIFAP Matamoros focused on improving feedstock production (alfalfa and silage production) and animal nutrition to increase the productivity of cows. Since ITESM La Laguna set up in the region, it has provided training programmes for farmers to improve their farming management capabilities. The well-developed networks of suppliers of inputs for agriculture and milk production have been supporting the transformation of capabilities of farmers. The exceptional case of Madero Equipos de Ordeño supported increasing codification of regional farming knowledge. In dairy production, Lala (and possibly Chilchota) have developed alliances with foreign firms for technology development and transfer for packaging materials, dairy technologies and quality standardisation of processes and operations.

In Los Altos and Tabasco, the learning networks have focused on improving the routines related to all the technological components following the intensive milk production model. In Los Altos, FUNPROJAL designed and implemented its research agenda and training for family milk production units with UGR Jalisco and Universidad de Guadalajara, SEDAGRO, JADEFO and CIPEJ. Holstein Mexico carried out annual CIGAL and PROLECHE technical events for updating technologies. Some DEPAI and GGAVATT groups have succeeded in technology transfer and COFOCALEC supplies training for the standardisation and certification of dairy products and processes.

In Tabasco, Fundación Produce Tabasco and UGR Tabasco and suppliers of inputs for agriculture and dairy production organised the tropical dairy forum. INIFAP Huimanguillo and Balancán, Fundación Produce Tabasco, Fundación Tabasco, SEDAFOP and DCyREMA designed and implemented training programmes for dual-purpose systems. Some GGAVATT groups were implemented in technology transfer. For artisan cheese production, small cheese processors, Fundación Tabasco and CIATEJ have been working to get PDO for ‘de Poro’ cheese. In all regions, Nestlé and suppliers of inputs for milk and dairy have played a core role in improving milk-farming practices, including the use of technologies and the development of infrastructure to chill milk, although this infrastructure is still incomplete.

The networks for supplying economic resources to dairy farmers show that the main actors have been dairy firms: in La Laguna, Chilchota and UCIALSA (part of Grupo Lala); in Los Altos, Lechera Guadalajara and Sigma Alimentos; and in Tabasco, UCG Tabasco and Nestlé. To a lesser extent FIRA, FIRCO, Financiera Rural, and the Alianza para el Campo programme provided some resources for building dairy infrastructure.

Regarding the networks for technical support for milk production, in La Laguna and Los Altos regions, there were well-established procedures among leading dairy firms to check milk quality and to assist dairy farmers. In Tabasco, Nestlé has supported farmers since it came to the region also with well-established procedures, and increasingly Ultralácteos has set up chilling tanks and checking points for the quality of milk to support farmers in improving its milk catchments. In the control of bovine diseases, SEDAFOP has set up guidelines and UGR Tabasco together with UCG Tabasco and Nestlé have all provided technical support to improve the health of the herd in the region aiming to improve the productivity of the farms. In addition, “Ganaderos” has developed networks for supplying inputs for agriculture and milk production and increasingly technical support.

The leaders in dairy production, Lala and Sigma Alimentos R&D departments developed networks and alliances with international firms and have substantially improved their capabilities for dairy production and commercialisation. Other firms in the regions have relied on national suppliers and their own R&D capabilities. However, their achievements have been modest.

In summary, the regional dairy structures show that La Laguna has a highly integrated value chain of large specialised dairy farmers and a few dairy firms compared with the other two regions. High quality milk is institutionalised as are technology transfer processes and arrangements for milk production and commercialisation, with the participation of a few organisations. Tabasco and Los Altos regions, on the other hand, have more complex structures because they integrate heterogeneous and numerous dairy farmers and firms. These structures are supported by numerous public and private organisations, employing complex networks and institutional arrangements and with fewer economic resources to build infrastructure and deliver training in support of capabilities development.

6.2 Comparison of the economic outcomes of the dairy regions

NAFTA threatened dairy farmers and dairy processors but also provided new impetus to accessing, adapting and adopting technologies. Dairy regions’ actors responded according to their accumulated capabilities, economic capacities, regional networks, institutions, and constraints such as cultural differences (e.g. the degree of trust among farmers, dairy firms and government organisations). These factors have influenced the development of regional capabilities, which are associated with the economic growth of milk and dairy production. The results for milk and dairy production show that La Laguna outperforms Los Altos and Tabasco.

Milk production and commercialisation

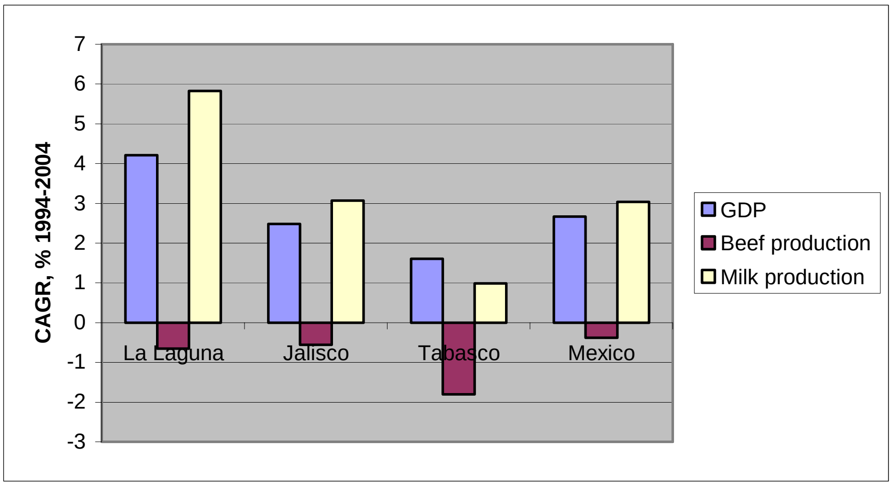
Milk production in La Laguna grew faster than in the other two regions resulting in expansion of its share in national production. Los Altos outperformed Tabasco, which had the lowest milk production growth; lower than the average for tropical regions in Mexico although only a moderate decline in similar share of national production (see Table 6.1). However, it has continued to have lower productivity of cows compared with other similar grazing-based systems around the world (see Table 5.21). Since the CAGR of the milking herd grew faster than the CAGR of milk production in Jalisco and Tabasco, it can be concluded that their average productivities were lower than those of La Laguna. The productivity of La Laguna cows (17-26 litres per day per cow) is clearly higher than in Los Altos (14-23 litres per day per cow) and Tabasco (1.5-10 litres per day per cow) (see also Tables 6.3a and 6.3b).

Table 6.1 Changes in the indicators of economic outcome of the dairy regions, 1994-2004

Selected region (Total of the climate regions)	La Laguna, (Arid and semi-arid regions)	Los Altos[1] (Temperate regions)	Tabasco, (Tropical regions)
CAGR of milk production, (3.04% MDS)	5.83% (4.06%)	3.07% (2.60%)	0.99% (2.21%)
Change in the share of national milk production	15.87% to 20.72% (32.85% to 36.25%)	17.18% to 17.23% (49.96% to 47.89%)	1.23% to 1.01% (17.19% to 15.85%)
CAGR of size of dairy herd, (3.20% MDS)	4.94% (4.47%)	8.63% (3.84%)	3.84% (-2.81%)
Share in total of national dairy herd	20.00% to 23.64% (38.68% to 43.68%)	6.05 to 10.10% (44.01% to 46.82%)	0.80% to 0.82% (9.50% to 17.31%)

[1]These figures are for Jalisco, since figures for 1994 by municipality are not available.
Source: Author's elaboration with data from SAGARPA 2000 and 2005.

It should be noted that milk production grew faster than beef production in all the regions (see Figure 6.1). This suggests that milk production is becoming an attractive economic activity with higher cash flow and liquidity even in the areas where the dual-purpose system of production is used, although dairy farms' profitability appears to be lower in these dual-purpose systems (Odermatt and Santiago Cruz 1997; FIRA 2001).



Source: Author's elaboration of data from SAGARPA (2005) and SIAP (2005).

Figure 6.1 Regions' growth rates of beef and milk production

All the regions showed increasing concentration of milk production in a few municipalities. This suggests the formation of clusters of dairy farmers, who increasingly specialised in milk production over beef production, even in the tropical regions, where milk production is becoming an industrial process (small farmers integrated into the value chains of the large dairy firms Ultralácteos and Nestlé) (Alvarez Macías 2005). In addition, the number of dairy farmers seemed to be decreased.[307] Some of them were not able to engage in the transformation process either because of a lack of the resources needed to modernise their farms (catching up with best practice in dairy farming) or because they were not able to achieve sufficient scale to profit. Nevertheless, there has been an expansion in dairy processing in La Laguna and Los Altos, large firms have increased their milk catchment and new firms have set up in the regions (i.e. Sigma Alimentos, Parmalat and LICONSA in Los Altos). This reflects the accumulation of the capabilities of the dairy regions to produce high quality chilled milk and to offer the conditions for other firms to set up in Los Altos and to attract other large firms in the case of La Laguna, where Alpura and Nestlé collect

[307] There are no statistically reliable data available. There was agreement among interviewees and based on existing research (del Valle Rivera 2000, Martínez Borrego and Salas Quintanal, 2002; Muñoz Rodríguez, García Muñiz, et al. 2003) that the number of farmers had decreased, estimations of 70,000 in 1991 vs. 60,000 in 2005.

chilled milk. Furthermore, there has been an expansion of some firms to other regions (e.g. Lala buying dairy facilities and Lechera Guadalajara building new dairy facilities). Tabasco's results show that despite changes in farming and dairying capabilities, these changes were not enough to support the growth of milk and dairy production at the same rate as in the other regions. Furthermore, there is a lack of infrastructure for chilling milk, and many farmers appear not to have reached an efficient scale of milk production, a shortcoming that limits their profitability compared with specialised systems. However, in terms of efficiency in the use of resources, it might be that Tabasco farmers have achieved better overall results (meat and dairy combined) than the dairy-specialised farms in La Laguna and Los Altos, as was found in Veracruz (another tropical region) (Odermatt and Santiago Cruz 1997; FIRA 2001). This might explain the prevalence of small producers in regions, regardless of their low productivity and profitability in milk production. Table 6.2 presents a summary of the main changes in the industrial structure of the dairy regions.

Table 6.2 Main changes in the industrial structure of the dairy regions by 2005

Region	La Laguna	Los Altos	Tabasco
Concentration of milk production in the region	5 municipalities, 97% (1998)	19 municipalities of Los Altos, 62%; others 105 municipalities, 38% (2004)	10 municipalities, 97% (2000)
Number of dairy farmers	Decreasing <1,650 (2005)	Decreasing ~16,000 (2005) in Jalisco	Decreasing ~6,200 (2005)
Industrial dairy production	Large growth of Lala and Chilchota and Alpura and Nestlé collecting milk in the region	Large growth of Lechera Guadalajara and Nestlé and setting-up of Alimentos La Concordia, Lala and Sigma Alimentos	Moderate growth of Ultralácteos and Nestlé collecting milk Continuing participation of artisan cheese processors

Source: Author's elaboration.

Dairy industrialisation

As we noted in Table 2.10, Mexican dairy production has increased at a CAGR of 2.62% in the period 1994 to 2004, similar to GDP (2.67%), but lower than for milk production (3.04%). This might suggest that more milk is consumed without any treatment and/or bottled in plastic and Tetra Pak™; and UHT milk in Tetra Brick™. The dairy products with the highest growth are yogurt (12.40%), butyric fat (8.63%), cream (10.30%), UHT milk (7.10%) and some types of cheese (i.e. Oaxaca, 5.57% and Panela, 5.75%). These results indicate that changes have occurred in the dairy production capabilities of the regions. These results are further supported by the growth of milk production capabilities of dairy farmers and dairy firm catchments, e.g. Lala, Lechera Guadalajara, Alimentos La Concordia and Ultralácteos. These firms have dominated the market for UHT milk and long-shelf life milk in plastic containers. The rapid growth in the yogurt and cheese markets can be explained to a certain extent by the development of capabilities by Lala, Chilchota, Lechera Guadalajara, the emergence of Sigma Alimentos and Alimentos La Concordia and increasingly, of the artisan cheese makers for regional cheeses in Los Altos ('Cotija' cheese) and Tabasco ('de Poro' cheese).

The dairy regions' growth has been accompanied by the accumulation of capabilities of the firms, not just in R&D for dairy production, but also they have accumulated capabilities in marketing, operation, logistics, etc., which led them to expand regional production, and to increase distribution centres and marketing infrastructures. Lala, Nestlé, Chilchota, Sigma Alimentos and LICONSA all have national markets and Lala, Chilchota and Sigma Alimentos increasingly export dairy products. Alimentos La Concordia and Ultralácteos are still regional firms, although they have some distribution in the main consumption centres (e.g. Alimentos La Concordia in Mexico City and Guadalajara; and Ultralácteos in Mexico City and Veracruz) (see Table 6.4). This fast growth of La Laguna and Los Altos since NAFTA has contributed to market maturity (Euromonitor 2005). However, it might be expected that demand will increase faster in the future if the economic situation of the country improves (Dobson 2002; Dobson 2003).

In summary, CAGRs of milk production in the MDS (3.04%) and dairy production (2.62%) have grown faster than the average annual rate of growth of the population (1.79%) (see Table 2.12) and have been similar to GDP (2.67%). However, this growth has not been sufficient to meet the Federal government goal to become self-sufficient in good quality milk and dairy products for all the population, including the low-income groups. Imports of dairy have increased at a higher rate (3.78%) than domestic milk and dairy production.

6.3 Intra and inter organisational capabilities in dairy regions

It is clear that the economic performance of the regions has been uneven, which can be explained by the accumulation of regional capabilities. The evolution of intra organisational capabilities of dairy farmers and firms' expansion have been based on changing their existing technological and organisational routines and capabilities in dairy farming following the international technological trends of the intensive model system and dairy technologies to improve cow productivity and to increase the production and commercialisation of high quality chilled milk and dairy products.[308]

In La Laguna, technological and organisational capabilities have been mastered by many of the dairy farmers (some of whom are also shareholders of Lala) to produce a homogeneous supply of high quality chilled milk (see Table 5.6), and by Lala and Chilchota to develop new products and processes (see Table 5.7). Farmers increasingly have learned how to increase the productivity of cows through improving their routines regarding increasing use of artificial insemination and the use of transplanted embryos and sexed semen, for which suppliers of those inputs have helped farmers to use the techniques. These changes eventually have improved the genetics of the regional herd. In order to improve the capabilities of herd management, farmers have improved their routines to produce alfalfa, the main feedstock and increasingly using forage and silage to lower the cost of milk production. Professionals have assisted dairy farmers regularly and introduced changes in milking, farming design, etc. (see Table 5.2). All these changes in the farmers' sets of routines contributed to the outstanding development of intra and inter organisational capabilities of La Laguna for milk production and commercialisation (Table 5.6). Improvement in the networks for learning in the regions (e.g. PIAL project and ENGALEC) facilitated technology transfer capabilities for the appropriation and use of technologies in the region. However, it is important to notice that UCIALSA, FIRA, FIRCO and farmers provided the resources for the acquisition of technologies (e.g. chilling tanks, specialised cows, etc.), supporting the conditions to improve milk production capabilities in the region, policies similar to those indicated by von Tunzelmann (2009, p 436) who has advocated the need for complementary investments in capabilities development.

In the case of dairy processors, Lala has grown fast acquiring dairy facilities around the country and integrating dairy farmers beside La Laguna in Jalisco, Veracruz, Yucatán and Baja California, to become the leader in bottled fresh milk. Lala also had alliances

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[308] The analysis is based on the 'stylised' sector-specific regional capabilities proposed in Table 4.2, and the proposed specific capabilities for milk production, Table 4.7, and dairy production, Table 4.8.

with foreign firms to develop new products and its management development has led the firm to become the leader in the dairy market. Lala and Chilchota expanded into the national market and started exporting.

The rapid growth of La Laguna can be attributed to the accumulation of intra and inter organisational capabilities (see Tables 5.6 and 5.7) that led to the highly integrated value chain of dairy farmers and dairy processors. They have been supported by well-structured suppliers of inputs and services for milk and dairy production. Their collective activities/mechanisms/processes have contributed to better alignment of actors and coherence for the functions (Table 5.8) that can be linked to the outperformance of the region in milk and dairy production.

In Los Altos, there has been a transformation among family dairy farms towards the specialised model for milk production, resulting in economic benefits, increased productivity on the farms and improved milk quality (see Table 5.17). As a result, the region’s dairy production has grown rapidly. Lechera Guadalajara set up Alimentos La Concordia and expanded its capacity to other states, Nestlé increased its collection of milk as well as LICONSA, and Parmalat (now Lala) and Sigma Alimentos set up in the region (see Table 5.18).

Tabasco has increasingly introduced technology into the dual-purpose systems towards a more specialised system of production (see Table 5.20). However, it has had problems in integrating the value chain and modernising. Improvement in chilled milk quality has led to better integration of dairy farmers with Ultralácteos and Nestlé. The non-integrated milk farmers have followed a technological trajectory of producing artisan cheese, which might have other implications for the future sustainability of the tropical region. The ‘modernisation’ of the ‘de Poro’ cheese might provide the means for reaching the scale of production and economic capacity (i.e. organisation for commercialisation) (see Table 5.26) to meet the demands of the large retailers.

In summary, changes in milk production capabilities within the farms were the result of different degrees of farmers’ introduction of technological components and coordinated practices or routines towards a specialised milk production system, i.e. intra organisational capabilities addressing improvement in technological capabilities in herd management systems, including herd genetics, control of diseases, hygiene practices and milking and milk conservation systems, and the organisation of the farmers to higher integration of regional value chains (inter organisational capabilities) (see criteria in Table 4.7). As result, farmers increasingly produced greater amounts of chilled milk of high quality for industrialisation. These changes in routines, which supported the improvement of technological and organisational capabilities of the dairy farms in the regions, were carried out by dairy processors, suppliers of milk production inputs and INIFAP and Fundaciones Produce (see subsection 7.1.1). They did so through technical support and development programmes, which helped farmers to change their farming routines into new intra organisational capabilities and evolve inter organisational capabilities in the regions – the higher the adoption of technological components of the intensive model for milk production by larger numbers of farmers, the better the development of the inter organisational capabilities for milk production. Summaries of the state of the main regional capabilities achieved for milk production are provided in Tables 6.3a and 6.3b with some performance indicators.

Table 6.3a State of main intra organisations regional capabilities achieved for milk production by 2005

Intra Organisational Capabilities	**La Laguna**	**Los Altos**	**Tabasco**
	Some indicators		
Herd management capabilities to use intensive milk production systems	Specialisation (96% of milk production comes from specialised farms and 4% from family system)	Transition (38% of farms are classified as semi-specialised and specialised farms, 85 to 90% are family systems)	Transition of dual-purpose towards more specialised systems (~100% are family systems)
Capabilities for improving herd genetics	~100% of specialised dairy cows	38% of the herd is improved crossbreeds and specialised dairy cows	98% of crossbreeds showing some heterosis
Agricultural capabilities for feedstock production to improve animal nutrition	Specialisation in the production and use of alfalfa and grains in specialised systems and combined feedstock and grazing in family systems	Improvements in combining feedstock production and grazing systems	Increasing use of intensive grazing with improved grasses and increasing use of forage, silage and animal supplements
Dairy Farming Capabilities	Specialisation	Transition	Transition
Use of mechanical milking by farmers	~ 80%	~ 46%	10 to 20%
Use of chilling systems	~100%	~86%	10 to 20%
Productivity per cow, l/day	17-26	14-23	1.5-10

Source: Author’s elaboration from cases and Tables 5.1, 5.2, 5.6, 5.9, S5.6, 5.17, 5.20, 5.25.

Table 6.3b State of main inter organisations regional capabilities achieved for milk production by 2005

Inter Organisational Capabilities	**La Laguna**	**Los Altos**	**Tabasco**
	Some indicators		
Research capabilities	Specialisation in agricultural capabilities in forage and alfalfa production and in animal nutrition (INIFAP Matamoros)	Capabilities for improving milk farming practices and for improving practices in artisan cheese production (SEDAGRO, CIATEJ, UGR Jalisco and CIPEJ)	Agricultural capabilities in intensive grazing systems and higher educational capabilities (i.e. Master and PhD programmes) INIFAP Tabasco and COLPOS Cárdenas)
Collaborative capabilities to legitimate intensive model practices for milk production	Culture of high quality chilled milk	Development of the culture of high quality chilled milk	Transition towards a culture of high quality chilled milk
Technology transfer capabilities for diffusing the practices of intensive milk production systems	PIAL project, ITESM and ENGALEC training programmes Technical support of Lala and Chilchota for dairy farmers	Few DEPAI and GGAVATT groups Technical support of Lechera Guadalajara, Alimentos La Concordia and Sigma Alimentos for farmers	Few DEPAI and GGAVATT groups Technical support of Ultralácteos and Nestlé for dairy farmers
Relational capabilities for mobilising economic resources	Strong support of financial networks based on private and public resources (UCIALSA and FIRA)	Good support of financial networks based on public resources and private (Lechera Guadalajara, Alimentos la Concordia, Nestlé, Sigma Alimentos and FIRA)	Weak support of financial networks based on public and private resources (SEDAFOP, UCG Tabasco and Nestlé)
Animal disease control capabilities	Control[1] Collaborative activities of SAGARPA La Laguna, UGR La Laguna and dairy farmers	Control[1] Collaborative activities of SEDAGRO, UGR Jalisco and dairy farmers	Control[1] Collaborative activities of SEDAFOP, UGR Tabasco and CFPPET and dairy farmers
Capabilities for development of suppliers for agriculture and dairy farming	Farms' design and operation capabilities Expansion of services of Madero Equipos de Ordeño	Creating a network of suppliers for feedstock and heifers	Production of seeds for grazing
Organisational capabilities to chill milk for industrialisation	Approximately 98%	80- 90%	60-70%
Organisational capabilities for development	Collaborative activities of PIAL, UCIALSA, FIRA, INIFAP and Alianza para el Campo for milk production	Collaborative activities of FUNPROJAL, SEDAGRO, UGR Jalisco, COFOCALEC, SEDER and dairy farmers for milk production and standardisation of the industry	Collaborative activities of SEDAFOP, UGR Tabasco and CFPPET and dairy farmers to improve milk production and quality
Capabilities to attract new firms in the business	Increasing collection of milk by Alpura and Nestlé	Setting up of Alimentos La Concordia, Sigma Alimentos, and Parmalat	Activities of Fundación Tabasco and GERSSE for milk and artisan cheese production project
CAGR of milk production (1994-2004)	5.83% vs. 3.04% (MDS)	3.07% vs. 3.04% (MDS)	0.99% vs. 3.04% (MDS)

[1]Control: First stage of disease eradication, but still frequent outbreaks. According to regional SAGARPA officers, the occurrence of animal disease has lessened in each of the regions (see Table S6.1) through concerted and collaborative activities among SAGARPA regional offices and regional dairy farmers' associations.

Source: Author's elaboration from cases and Tables 5.1, 5.2, 5.6, 5.9, S5.6, 5.17, 5.20, 5.25.

Regarding dairy production, the state of regional capabilities and some performance indicators are summarised in Table 6.4 (see criteria in Table 4.8). The intra organisational capabilities included firm's R&D capabilities (i.e. Lala, Nestlé, Chilchota, Sigma Alimentos and LICONSA) for the development of new products, production capabilities and marketing and branding capabilities. They have all developed important logistic capabilities to expand into the national market. To a lesser extent, Alimentos La Concordia and Ultralácteos are still regional firms, although they have some distribution centres in main consumption centres. For instance, Alimentos La Concordia sells bottled fresh milk in Mexico City and Guadalajara and Ultralácteos sells UHT milk in Mexico City and Veracruz. Lala, Lechera Guadalajara, Alimentos La Concordia and Ultralácteos have dominated the market of long-shelf life milk in plastic containers and UHT milk. In the same vein, the rapid growth in yogurt and cheese markets can be explained by the development of new products by Lala, Chilchota, Lechera Guadalajara, the emergence of Sigma Alimentos and Alimentos La Concordia and the persistence of the artisan cheese makers in Los Altos and Tabasco.

The main changes in inter organisational regional capabilities for dairy production were in the development of alliances with national and foreign suppliers of technology and inputs for dairy production by Lala in La Laguna and Sigma Alimentos and Lechera Guadalajara in Jalisco.

Table 6.4 State of regional capabilities achieved for dairy production by 2006

La Laguna						
Intra organisational capabilities	**Lala**		**Chilchota**			
Some indicators						
R&D capabilities for dairy technologies	42 types of dairy products		34 types of dairy products			
Dairy production capabilities	16 dairy facilities in 10 states (next expansion in Central America) (29 firms in the corporation)		1 dairy facility in Torreón (12 firms in the corporation)			
Marketing and branding capabilities	National market with 128 distribution centres and 8 brands and foreign markets		National market in 21 states and foreign market in the US with 15 brands			
Inter organisational capabilities	**Lala**		**Chilchota**			
Alliance making and acquisition capabilities	National and foreign suppliers		ND			
Los Altos						
Intra organisational capabilities	**Lechera Guadalajara**	**Alimentos La Concordia**	**Nestlé (MNC)**	**Sigma Alimentos**	**LICONSA**	**Artisan cheese processors**
Some indicators						
R&D capabilities for dairy technologies	12 types of dairy products	11 types of dairy products	36 types of dairy products	36 types of dairy products	4 types of dairy products	
Dairy production capabilities	4 dairy facilities in 3 states	1 dairy facility	7 dairy facilities in 5 states	3 dairy facilities in 3 states 2 facilities, Costa Rica and the Dominican Republic	10 dairy facilities in 8 states	
Marketing and branding capabilities	National in 23 states with 43 distribution centres with one brand	Regional with distribution centres in 7 states with one brand	National with 21 distri-bution centres with 10 brands	National in 27 states with more than 100 distribution centres, also Central America with 30 brands	National with around 1800 selling points with one brand	
Inter organisational capabilities	**Lechera Guadalajara**	**Alimentos La Concordia**	**Nestlé (MNC)**	**Sigma Alimentos**	**LICONSA**	**Artisan cheese processors**
Alliance making and acquisition capabilities	National and foreign suppliers	ND	ND	National and foreign suppliers	ND	
Organisational capabilities to develop PDO for regional cheeses						PDO for "Cotija" cheese
Tabasco						
Intra organisational capabilities	Ultralácteos		Artisan cheese processors			
Some indicators						
R&D capabilities for dairy technologies	15 types of dairy products with one brand		Many types of fresh cheese ('de Poro', Oaxaca, Panela or Asadero, Double cream Tabasco) produced with non-pasteurised milk with several regional brands			
Dairy production capabilities	1 dairy facility		Approximately 200 small dairy facilities			
Marketing and branding capabilities	Regional market in 7 states with 10 distribution centres with one brand		Regional market and brands and/or sold in bulk without brand			
Inter organisational capabilities to develop PDO for regional cheeses			In process to obtain PDO for "de Poro Cheese"			

Sources: Author's elaboration with information from Chapter 5, Tables 5.8, 5.19 and 5.27, firms' reports and websites retrieved in September 2006.
Lala's website: http://www.lala.com.mx
Chilchota's website: http://www.chilchota.com/index_productos.htm
Lechera Guadalajara' s website: http://www.sellorojo.com.mx/
Alimentos la Concordia's website: http://www.aldia.com.mx/home.html
Sigma Alimentos's website: http://www.sigma-alimentos.com/
Nestlé's website: http://www.nestle.com.mx/nuestras_marcas/home_categorias.asp
Ultralácteos' website: http://Ultralácteos.com.mx/n_productos.html

6.4 Capabilities contributions to functions and dysfunctions in dairy regional systems

Using the analytical framework referred to in section 4.2 and the assessment of achievements in the dairy regions carried out in sections 6.1, 6.2, and 6.3, this section identifies and analyses the capabilities accumulated in the three regions which contributed to functions and/or dysfunctions (see also Tables 5.8, 5.19 and 5.27). These capabilities are then assessed following the criteria established in subsection 4.4.3: basic capabilities, operational capabilities and strategic capabilities, which are presented as follows in subsection 6.4.1. In a similar way, analysis of the dysfunction is carried out in 6.4.2 and section 6.5 develops a set of regional policy recommendations.

6.4.1 Capabilities that contribute to functions

Developing positive externalities

GATT and NAFTA changed the expectations of all the actors and were perceived as both a threat and/or an opportunity by different actors whose formal and informal interactions changed in different ways. Central government organisations SAGARPA, INIFAP and FIRA changed their structures and developed specific policies and institutional arrangements (e.g. PROCAMPO/Alianza para el Campo and states' Fundaciones Produce)[309] (see Table 2.2) to support the development of capabilities among dairy farmers through technology transfer processes from INIFAP (regional agencies) to dairy farmers. These processes of technology transfer implied that INIFAP regional research organisations developed specific knowledge and capabilities to attend to regional demands together with other regional organisations (e.g. PIAL projects, DECyREMA training programme, DEPAI and GGAVATT groups) and trained the extension agriculture agents to train farmers in specific technological areas (user-producer interactions) to improve routines and capabilities within farms. These mechanisms of technology transfer, although to a certain extent dysfunctional due to the small number of attendees that could be trained by the reduced number of extension agents, supported the evolution of intra organisational capabilities within farms. These top-down approaches were implemented according to the structures, institutions and networks in the dairy regions, which happened to benefit the better-off large farmers in

[309] Those changes affected all agricultural sectors and regions.

all the regions, because they were able to attract the resources from FIRA and Alianza para el Campo to improve their technological infrastructure. Therefore, the combination of training programmes and availability of resources to improve dairy infrastructure contributed to dairy farming capabilities evolution in all the regions, although creating structural disparities in the accumulated capabilities in the regions.

The networks of suppliers of inputs for milk and dairy production (e.g. ‘Ganaderos’, CIGAL and ENGALEC) and the collective efforts of the organisations dealing with animal disease control (SAGARPA regional offices, cattlemen’s associations and dairy farmers) improved the production and quality of milk and attracted new firms to the regions (i.e. La Laguna and Los Altos).

In the case of artisan cheese production, Fundación Tabasco and Fundación Produce Tabasco, artisan cheese producers and CIATEJ have been working together to develop some inter organisational capabilities to improve artisan cheese production techniques to obtain a PDO for “de Poro” cheese.

Creating and diffusing knowledge

Dairy farmers and dairy firms have acquired, adapted and diffused technologies, new to the dairy regions, although not necessarily new to other dairy systems in the world. Since these technologies were originally developed for specialised cows for milk production in developed countries, adaptations were needed, including herd management practices (i.e. animal health, reproduction and nutrition). In this sense, there may be ‘pieces of regional tacit knowledge’ that might be new to global dairy production. For instance, for the dual-purpose systems in Tabasco (and in other tropical regions), two important technological innovations were introduced: a) development of crossbreeds that have been adapted to and reached a certain degree of heterosis; and b) development of new techniques and new seeds for grassland for intensive grazing systems. These changes were the results of the increasing use of technologies (e.g., artificial insemination, agricultural practices, increasing use of mechanical milking, etc.) that changed the technological routines and capabilities of farmers.

In La Laguna and Jalisco, some collaborative projects have focused on compost production from manure using earthworm cultures (e.g. FUNPROJAL and Universidad de Guadalajara) and the recycling of water from dairy farms for agricultural purposes (e.g. PIAL projects). In La Laguna, INIFAP Matamoros, UAAAN, UNAM, UACh, and UGR La Laguna have produced technical publications on dairying, and been involved in the publication of books and papers, and projects with farmers in other dairy systems (e.g. Querétaro, Chihuahua and Aguascalientes). In Jalisco, FUNPROJAL has produced and distributed bulletins among farmers to help them improve milk production, and COFOCALEC has developed infrastructure for standardisation of the dairy industry. In Tabasco, INIFAP Tabasco and Fundación Produce Tabasco produce technical reports on grazing systems and dual-purpose milk production; and DEPAI and GGAVATT method and DCyREMA are used by government to diffuse dairy farm technologies from INIFAP to farmers in Los Altos and Tabasco.

However, the diffusion of the best practices for milk production has only reached a small population of numerous farmers because the technology transfer methods require an extensive process of user-producer interactions, which has not yet happened to cover the large population of farmers. Furthermore, on average, the professional profile of farmers in these regions is suspected to be lower than in La Laguna (Alvarez Macías 2005; Cervantes Escoto 2005; Salas Quintanal 2005), although there are no definitive data available on this.

In dairy processing, industrial processes were set up to deal with integration of the heterogeneous quality of milk from farmers in Los Altos and Tabasco, but less so for La Laguna with its homogeneous high quality milk supply. However, the differences among R&D capabilities show that large firms, Lala and Sigma Alimentos, have developed substantial changes in their intra organisational capabilities to produce new dairy products and to expand their markets. These accumulations are the results of well-structured R&D departments compared with Lechera Guadalajara and Alimentos La Concordia. They have held systematic training for the development and acquisition of dairy technologies and other managerial capabilities (e.g. project management, logistics etc.) with suppliers of technologies and consultants. For instance, acquisition base, relational capabilities[310] and marketing capabilities have led the expansion of Lala and

[310] These capabilities include selection, identification, and reconfiguration of technologies, which allow firms to recognise when an acquisition would be appropriate for obtaining new resources (Anand, Capron

Sigma Alimentos, via the acquisition of dairy facilities and brands, and establishment of new dairy facilities outside Jalisco in the case of Lechera Guadalajara. Strategic capabilities for searching, alliance making and licensing technologies, to acquire and adapt products, have also been developed by Lala and Sigma Alimentos.[311] In addition, these firms have the financial resources to develop and implement new projects, which have led their rapid growth in the national and increasingly in foreign markets.

Driving the research processes

The research capabilities that contributed to this function are the result of more participative processes of actors to focus their research on regional needs. The emergence of new organisations for agricultural development and policies (e.g. Fundación Produce La Laguna, FUNPROJAL, Fundación Produce Tabasco, Fundación Tabasco, PROCAMPO and Alianza para el Campo) and the transformation of INIFAP and FIRA's focus on regional development have contributed to search for the relevant projects in the regions to improve the production of feedstock (e.g. PIAL projects have helped to improve the production of alfalfa and grains, the most important cost in milk production in La Laguna). In Los Altos, CIPEJ and FUNPROJAL have worked together to improve farm management capabilities, which were identified as one of the required capabilities for family farmers, more generally through the DEPAI and GGAVATT groups. In Tabasco, INIFAP Tabasco, Fundación Produce Tabasco, Fundación Tabasco and COLPOS Cárdenas have been researching intensive grazing systems and the use of endogenous plants for animal nutrition. Additionally, regional dairy research has been conducted in La Laguna and Los Altos aimed at social and economic sustainability of the regions.

Entrepreneurial experimentation

The evidence in this research shows that business and engineering capabilities of existing large dairy firms have changed the capabilities in La Laguna and Los Altos to expand production capacity. Lala and Lechera Guadalajara have been able to interpret the market signals and translate them into specific projects to expand their business

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et al. 2005). Acquisition capability is a relational capability, which is defined as the capacity to purposefully create, extend or modify the firm's resources base, augmented to include the resources of its alliance partner (Dyer and Singh 1998; Dyer, Kale et al. 2004).

[311] These firms have been able to use state of the art technologies acquired for the production of nutritious and healthier dairy products (improved functionality), packaging systems for high quality milk (e.g. long-life pasteurised milk) and logistics systems for distribution.

through either acquisitions of other dairy facilities, in the case of Lala at a national level, or building up new facilities within the region – the case of Lechera Guadalajara participating in the building up of Alimentos La Concordia – and other facilities in other states. However, the improvement in the milk production capabilities of the region has attracted new firms to set up in the region, i.e. Sigma Alimentos, Parmalat (now Lala) and the expansion of Nestlé. In so doing, they "pulled" farmers and other organisations to work together to create the networks of high quality chilled milk.

Additionally, suppliers of inputs and services for milk production have developed capabilities to design and operate specialised farms, e.g. Madero Equipos de Ordeño in La Laguna. In Tabasco, INIFAP Tabasco, COLPOS Cárdenas and Semillas Papalotla developed new grazing seeds in a joint project. The improvement of those capabilities helped farmers increasingly to use new seeds and grazing techniques to improve milk production.

Facilitating the formation of markets

The inter organisational capabilities for milk production that contributed to this function were developed through the networks of suppliers of high quality chilled milk in La Laguna (i.e. Lala and Chilchota), which attracted Nestlé and Alpura to buy milk. Los Altos followed the trend in La Laguna in increasingly improving its network of suppliers of high quality chilled milk and suppliers of feedstock. All the dairy regions have expanded their markets, but La Laguna and Los Altos have also entered international markets (e.g. logistics, marketing and branding capabilities of Lala, Madero Equipos de Ordeño, Sigma Alimentos and Chilchota). In Tabasco, the networks of milk suppliers of chilled milk have improved with the support and coordination processes of Ultralácteos and Nestlé.

Legitimation

The dairy regions have increasingly *legitimated* the practices towards an intensive model for high quality chilled milk production (which became and institutions in La Laguna and Los Altos) with different degrees of adaptation and appropriation of the technological components depending on the capabilities and economic capacities of the regional actors, who have 'agreed' to these changes (not without some problems). Some of these problems include: a) the displacement of farmers not able to invest in technological change; b) water shortage and contamination in La Laguna; c) increased production of manure and contamination of water in La Laguna; d) land erosion in tropical areas as a result of using new varieties of seeds; and e) a persistent problem of low profitability on farms in Tabasco, Los Altos and in some cases among small dairy farmers in La Laguna because of the absence of the scale required to make a profit using this model.

In addition, the production of regional cheeses with unpasteurised and non-chilled milk has been legitimated in Los Altos and Tabasco due to the development of the PDO for ‘Cotija’ and ‘de Poro’ cheeses.

Mobilising resources

The relational capabilities to create the networks to mobilise resources are certainly core capabilities that supported the creation of infrastructure to increase milk production. Large dairy farmers and firms provided these resources (i.e. economic support of Nestlé, Lechera Guadalajara, Alimentos la Concordia and Sigma Alimentos). The intervention of federal (i.e. SARH/SAGARPA) and state government organisations (i.e. SEDAGRO, CIPEJ and JADEFO in Jalisco, SEDAFOP in Tabasco and SAGARPA in La Laguna) provided additional resources through the programmes PROCAMPO/Alianza para el Campo and from UCIALSA, FIRA, FIRCO and Financiera Rural (e.g. ‘Tanques Rancheros programme’, in the 1990s in Jalisco and Los Altos).

Another important economic resource is the remittances from workers in the US, which have supported the infrastructure creation in Los Altos, and family labour in Los Altos and Tabasco. These resources are not easily captured in economic system accounting. However, they create a distortion of the milk production cost structure, and influence milk price negotiations between dairy farmers and dairy processors within the regions and at the national level (the case of LICONSA in Los Altos).

In the case of dairy processing, most of the resources to improve capabilities came from the enlarged R&D departments and investments in marketing, logistics and branding (e.g. Sigma Alimentos, Lala, Alimentos La Concordia, Lechera Guadalajara), with one exception from CONACYT that supported Sigma Alimentos for dairy processing.

Table 6.5 summarises the main capabilities accumulated in the dairy regions after NAFTA during the period of analysis and contributing to specific functions. They are classified into three types: basic capabilities (B); operational capabilities (O); and strategic capabilities (S) as proposed in subsection 4.4.3.[312] They are disaggregated in this way to develop policy recommendations in section 6.5.

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[312] (B) *basic capabilities* imply that regional actors have changed some of the technological and organisational routines; however, no major changes were observed in the performance of milk and dairy production (i.e. growth rate of milk and dairy production and development of new products lower than the country average); (O) *operational capabilities* imply that regional actors have changed some of the technological and organisational routines and improved the performance of milk and dairy production (i.e. growth rate of milk and dairy production and development of new products closer to the country average); and (S) *strategic capabilities* imply that regional actors have changed some of the technological and organisational routines and significantly improved the performance of milk and dairy production (i.e. growth rate of milk and dairy production and development of new products higher than the country average) and expanded into national and international markets.

Table 6.5 Capabilities that contributed to specific functions in dairy regions

Functions/Capabilities	**La Laguna**	**Los Altos**	**Tabasco**
Creating and diffusing knowledge			
Capabilities to improve cows' genetics (e.g., artificial insemination and crossbred production)	S	O	B
Herd management capabilities (i.e. animal health, nutrition and reproduction)	S	O	B
Agricultural capabilities for feedstock production and intensive grazing	O	O	B
Dairy farming capabilities (e.g., mechanised milking and implementation of chilling systems and best practices)	S	O	B
Technology transfer capabilities	O	O	B
R&D capabilities for dairy technologies	S	O	B
Driving research process			
Research capabilities addressing user-producer	O	B	B
Activities to support artisan cheese production	---	B	B
Entrepreneurial experimentation			
Dairy production capabilities (business and engineering capabilities for dairy production expansion)	S	S	B
Development of suppliers for agriculture and dairy farming (e.g. farm design and operation capabilities and production of seeds for grazing)	O	---	B
Facilitating the formation of markets			
Organisational capabilities that created networks of suppliers of high quality chilled milk and attracted new dairy firms	S	O	B
Marketing and branding for market expansion	S	O	B
Creating positive externalities			
Organisational capabilities to support regional development (e.g. Fundaciones Produce, FIRA, INIFAP and Alianza para el Campo)	S	O	B
Capabilities for controlling animal diseases	O	O	O
Alliance making and acquisition capabilities for dairy production	S	O	B
Capabilities for attracting new firms into the business	S	S	---
Legitimation			
Collaborative capabilities to legitimate intensive model practices for milk production (e.g. milk production capabilities that created a culture of high quality chilled milk)	S	O	B
Organisational capabilities to develop PDO for regional cheeses	---	B	B
Mobilising resources			
Relational capabilities for mobilising economic resources	S	O	B

(B) Basic capabilities, (O) Operational capabilities, and (S) Strategic capabilities.
Source: Author's elaboration.

6.4.2 Dysfunctions of the dairy regional systems to build capabilities

It is clear that the main capabilities developed in the regions are a technological and organisational mix in dairy farms and firms. However, the major dysfunctional patterns in the regions are the difficulties, the absence or underdevelopment of inter organisational capabilities to make actors' interactions more coherent and aligned (e.g. implementation of federal and state policies in the regions), in other words, more effective for building capabilities. To a certain extent these dysfunctions explain the poorer performance of Los Altos and Tabasco compared with La Laguna. The following analysis provides evidence of dysfunctions in the regions that should inform the development of future policies (section 6.5).

A lack of up-to-date education, research and limited training programmes are the main problems in the regions, especially in Los Altos and Tabasco where the number of farmers is much larger *(dysfunction in creating and diffusing knowledge)* than in La Laguna. For instance, the R&D capabilities of INIFAP have not been fully exploited because of insufficient capabilities for diffusing knowledge and practices from INIFAP researchers to farmers. There is poor updating of technology transfer processes (i.e. DEPAI and GGAVATT groups) including assessment of the effectiveness of the processes. Furthermore, the incentive systems of the SNI do not help technology transfer from INIFAP and the universities to dairy farmers *(dysfunction in driving the research process)*.

In the case of dairy processing, in all cases the dairy firms have been the instigators of the innovation process to develop new dairy products and markets relying on their own resources and foreign suppliers. There is evidence of a few interactions supported by government organisations to create capabilities (e.g. CONACYT supporting Sigma Alimentos dairy projects and some efforts of CIATEJ and Fundación Tabasco to support artisan cheese processors). There is no research on regional dairy technologies for sustainability.

This suggests that Mexican dairy regions depend on foreign alliances, and that there is a lack of strategic capabilities (dysfunctions) *to drive the direction of the research processes*. Some of the actors in the system did not perceive the opportunities or threats to the dairy sector when the market was opened (see the case of Tabasco). There was, and still is, no agro industrial policy to drive the direction of the research processes to create organisational capabilities in various areas:

a) To assess and mitigate, when necessary, the effects of the increased entry of dairy products.
b) To develop the technological and economic bases for the milk production systems in the regions (e.g. specialised, family and dual-purpose systems) and the projects and political instruments to induce the transformation of these systems to appropriate scales of production.
c) To create capabilities among farmers for water and slurry management in La Laguna and Los Altos.
d) To create a nationwide standardisation process for the dairy industry (i.e. norms, standards and infrastructure for their enforcement).
e) To create IPR laws and other instruments (e.g. PDO) to protect and enhance regional dairy production.
f) To conduct the research required to assess the socio-economic and environmental sustainability of new agricultural practices (e.g. increasing irrigation for alfalfa and other forage production) and their ecological impact on the region.
g) To update educational programmes for agriculture and technology transfer processes (e.g. DEPAI and GGAVATT groups).

In all regions, there has been a general lack of strategic capabilities for identifying opportunities to develop associated industries to supply inputs to the dairy sector *(dysfunctional entrepreneurial experimentation)* to cope with increasing demand (e.g. industrial production of heifers, semen, milking systems, etc.). Exceptions are Madero Equipos de Ordeño, 'Ganaderos' and Ordemex. High reliance on foreign suppliers is risky if the economic situation of a country worsens; therefore, the development of higher capabilities to implement complementary industries might be an opportunity for policy (e.g. tax credits or other incentives). [313]

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[313] This type of entrepreneurial experimentation refers to more extended types of capabilities development that are needed for the design and development of capital goods (milking systems, pasteurisation systems,

An interesting example of this lack of capabilities is in the tropical region where there was no industrial-scale development of crossbreed semen despite developments by INIFAP Veracruz (Castañeda Martínez 2005; Valdovinos Terán 2005). This might have attracted investors.

It is clear that the availability of a wide variety of dairy products in the markets transformed the dairy market. Consumers became aware of the different qualities and prices of dairy products, which created higher competition in the national market. However, the *dysfunction in facilitating market expansion* caused a lack of inter organisational capabilities to integrate fully small dairy farmers, who were not able to produce high quality chilled milk for industrialisation and make profit and or to consolidate artisan regional cheese-making based on unpasteurised milk in Tabasco and Los Altos. Furthermore, the collection of milk from LICONSA created an apparent distortion of the market for fresh milk in Los Altos.

Since NAFTA changed the trade rules, the *dysfunction in creating positive externalities* were the weak or inappropriate institutions to deal with:

a) the increasing import of milk preparations and dairy products had an effect in two ways. First, lack of understanding of the impact on milk production, which might have forced small dairy farmers to leave the business because of the inadequacy of a real level of protection from imports. And second, there were no mechanisms to verify the quantity and quality of imported industrial dairy goods. Therefore, the 'black market' increased, and production of milk substitutes and 'cheap dairy products' flourished and distorted the dairy market. The dairy substitutes industry supplied the quantities and prices demanded by the low-income population. The organisations for dairy standardisation products were in place (e.g. COFOCALEC, Secretariat of Health organisations and PROFECO), but enforcement of these standards was impossible due to the lack of infrastructure for inspecting the dairy processors;[314]

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packaging systems), farmers' services, semen and embryo production, etc., and the investment for these types of new firms.`

[314] It has been argued that large firms mixed these products with fresh milk in their industrial processes. These products are difficult to detect using a chemical test, and require industrial inspection.

b) LICONSA's role is not clear. It abandoned development activities in 1989, but continued with its social programme to reconstitute NFDM and complement it with the collection of fresh milk. This created unease among dairy farmers and dairy processors in some regions, e.g. Los Altos. Dairy processors argued that LICONSA was distorting fresh milk prices, by paying higher prices than those paid by the other dairy processors. Furthermore, they argued that LICONSA accepted lower quality milk than the large dairy processors, making the dairy farmers keen to sell their milk to LICONSA, and creating shortages for the dairy processors. This was a major problem for the dairy processors, who argued that LICONSA's practice did not encourage dairy farmers to improve their farming practices. The dairy farmers argued that LICONSA helped to increase the price of fresh milk in the region and that the quality of milk was good enough for LICONSA's needs (Guerra Márquez 2005b);
c) no means to deal with the lack of trust among the actors to promote regional and national changes (e.g. create industrial standards for the management of water and manure in specialised dairy farms, important for the sustainability of La Laguna and Los Altos dairy systems; nationwide standardisation of the dairy industry);
d) absence of inter organisational capabilities among regional actors to agree on a vision for the socio-economic sustainability of the dairy regions (i.e. strategic capability) was a clear dysfunction; and there were no collaborative projects to update the universities' and other research programmes to deal with dairy regional sustainability and to avoid the displacement of farmers. Furthermore, in La Laguna, problems relating to water supply and contamination of well water, were not resolved, and are threatening the sustainability of dairy production. In Los Altos, the transformation from family to specialised milk production systems missed inter organisational capabilities (i.e. management and administrative capabilities) to reach scale of production, since collective farms have proved not to be the solution. In the case of Tabasco, there were efforts to create a dairy cluster project to achieve the system's aims (Ceballos Falcón 2005; de la Peña Marshall 2005; Fernández Fernández 2005; Romero Villanueva 2005), but this did not include agreements to develop specific regional projects to support the project (e.g. industrial production of crossbreeding studs and semen, milking and chilling systems suitable for small tropical herds); and

e) lack of inter organisational capabilities to update the technology transfer programmes (DEPAI and GGAVATT groups), to develop environmental protection laws and to update the research systems incentives in the SNI to promote linkages between researchers and users (e.g. dairy farmers and other development organisations). This lack of capabilities might be a dysfunction of the whole Mexican innovation system, not just of the agricultural system.

The *increasing legitimation* of the intensive model systems has caused some problems. A lack of standardisation in the quality of fresh milk (chilled or non-chilled) has created tension among dairy farmers and dairy processors, including LICONSA in Los Altos. The over-exploitation of water for dairy farming and the ever-increasing production of manure, urine and air pollution have caused problems in La Laguna and Los Altos because of the lack of regulations for water supply, slurry management, air pollution, etc. In the case of Tabasco, the fact that 30-40% of the production milk is commercialised without pasteurisation mainly for the production of fresh cheese has specific demands. It requires the eradication of tuberculosis and brucellosis from the dairy herd, the introduction of intensive hygiene practices and development of a chilling infrastructure to maintain milk quality before processing to prevent other pathogens from affecting human health. Improving these practices, there is no good reason why production of cheese using unpasteurised milk should not be approved (it is used in France and Italy for mature cheese).

Finally, the *lack of resources to modernise small farms* seems to be a dysfunction in all the regions. The resources for developing and improving the capabilities in agriculture and milk production (i.e. Alianza para el Campo and DCyREMA, DEPAI, GGAVATT groups) have not been sufficient to cope with the large number of small farmers in Tabasco and Los Altos. The changes in FIRA favoured the large farmers and failed to support small farmers, except in some cases through dairy processors (e.g. Sigma Alimentos and Nestlé acting as ‘para financieras’), and where there have been some positive results.

The identification of dysfunctions and underdeveloped capabilities from Table 6.6 in the dairy regions provides the basis for identifying regional policy recommendations in the following section.

6.5 Regional policy recommendations

As pointed out in subsection 4.4.5, the key policy areas where government organisations have to intervene effectively in the development of the dairy regions are in strengthening their current capabilities and changing the institutional arrangements that have promoted or impeded their development.

Table 6.6 presents fourteen policy areas, which emerge from the analysis of regional dysfunctions and accumulated capabilities in the regions presented in Tables 5.8, 5.19, 5.27 and 6.5. These policies focus on the development of regional capabilities for future economic sustainability pursuing them in the short term (ST) and the long term (LT)[315] (see sub section 4.4.5). The policy areas are distinguished *by italics* for short term and when in **bold** signifies higher need in a specific region. This qualification is based on criteria and opinions expressed by interviewees about short- and long-term sustainability.

[315] (ST) is 1-6 years because the infrastructure and some institutions already exist; (LT) is over 6 years and implies a need for constructing infrastructure and further institutional changes. This timing was estimated taking into account the periods of implementation of the Alianza para el Campo programme as a general policy for the MDS and 6 years being the maximum presidential term, which implies possible coherence in the policies and activities of the actors.

Table 6.6 Policy areas for the Mexican dairy regions

Policy areas/Regions	La Laguna	Los Altos	Tabasco
Creating and diffusing knowledge			
1. Developing and diffusing regional endogenous dairy technologies (e.g. cows' genetics, regional cheese technologies, grazing systems, manure industrialisation, economic forage production, etc.) among small dairy farmers and dairy processors	LT	LT	LT
2. Integrated training programmes for specialised and non-specialised labour to improve technologies and organisation of work	*ST*	***ST***	***ST***
Driving the direction of search			
3. Expanding strategic infrastructure and institutions for the sustainable development of the dairy regions through collaborative research (e.g. collaborative activities of Fundaciones Produce and INIFAP research, CSPBL, Consejo Estatal de la Leche de Jalisco, etc.)	LT	LT	LT
Entrepreneurial experimentation			
4. Developing dairy supporting industries and services (e.g. production of forage, semen, heifers, milking and chilling systems, etc.) to reduce milk cost production	***ST***	***ST***	***ST***
Facilitating market expansion			
5. Developing networks of small milk suppliers and disentangling the role of LICONSA	ST	**ST**	ST
6. Developing marketing capabilities to expand regional products (e.g.'Cotija' and 'de Poro' cheeses) into national and international markets	*ST*	***ST***	***ST***
Legitimation			
7. Developing infrastructure for standardisation of dairy production (e.g. government organisations for industrial development, health organisations and testing labs for dairy imports and industrial control, COFOCALEC, PROFECO, etc.)	*ST*	***ST***	***ST***
8. Developing infrastructure for IPR laws (e.g. PDO) for regional products, socio-economic and environmental practices for regional development and legitimating the involved processes (see the cases of 'de Poro' cheese in Tabasco and Cotija'cheese in Los Altos)	*ST*	***ST***	***ST***
9. Supporting animal health programmes (e.g. tuberculosis, brucellosis and mastitis control) and inventory control (i.e. SENASICA) for planning purposes and possible legitimation of the production of artisan cheese without pasteurisation	*ST*	***ST***	***ST***
Mobilising resources			
10. Developing financial instruments to support infrastructure for small dairy farmers and firms	*ST*	***ST***	***ST***
11. Developing infrastructure for sustainable agricultural production (e.g. irrigation systems, manure management, water recycling, intensive grazing systems, etc.)	**LT**	LT	LT
Creating positive externalities			
12. Fitting the incentive systems for researchers to promote user-producer linkages (i.e. SNI)	*ST*	*ST*	*ST*
13. Searching the factors for social and economic sustainability of the regions to avoid unexpected consequences (e.g. displacement of small farmers, water overexploitation, erosion of land, possibilities of dumping of NFDM and milk preparation imports to avoid unfair trade, etc.)	*ST*	***ST***	***ST***
14. Updating rural and university education and research programmes focused on regional needs (e.g. updating DEPAI and GGAVATT groups, INIFAP research agenda, water and manure management, identifying sustainable economic models for milk production, modifying SAGARPA-FAO assessment projects, etc.)	LT	LT	LT

(ST) Short term (1-6 years); and (LT) Long term (over 6 years).
Source: Author's elaboration.

The implementation of a number of these policies needs to be region-specific because the priorities differ across regions. Thus, short-term and long-term policies across regions suggest that a national policy development, i.e. 'top-down' approach has to take into account these regional priorities for implementation.

La Laguna, Los Altos and Tabasco dairy regions are representative of arid and semi-arid, temperate and tropical regions respectively. If the economic sustainability of the MDS is a national objective, policies to support the development of capabilities for milk and dairy production in arid and semi-arid regions (besides La Laguna) should be directed to regions that already have more specialised milk production systems with some capabilities and can develop faster. Efforts should next be directed to the temperate regions since they may have accumulated capabilities that allow them to improve their performance in the short term. In terms of socio-economic sustainability, finding a way forward for the tropical as well as the temperate regions should be sought based on the fact that the numbers of farms (and farming families) in these regions are higher than in the arid and semi-arid regions. Policy priorities at regional levels are summarised below in Table 6.7.

Table 6.7 Summary of priorities of regional policy areas

Policy areas	La Laguna	Los Altos	Tabasco
Short term	2,**4**,5,6,7,8,9,10, 12, 13	**2**,**4**,**5**,**6**,**7**,**8**,**9**,**10,** 12, **13**	**2**,**4**,5,**6**,**7**,**8**,**9**,**10,** 12, **13**
Long term	1,3,**11**,14	1,3,11,14	1,3,11,14
Regions	(Arid and semi-arid regions)	(Temperate regions)	(Tropical regions)
Milk production growth rate, % (2004) (3.04% MDS)	5.83% (4.06%)	3.07% (2.60%)	0.99% (2.21%)
Share of the total of production, % (2004)	Increasing from 15.87% to 20.72% (32.85% to 36.25%)	Slightly increasing from 17.18% to 17.23% (49.96% to 47.89%)	Decreasing from 1.23% to 1.01% (17.19% to 15.85%)
Estimated number of milk farmers to attend (2004)	Lower than in the other two regions	Higher than in the La Laguna and Tabasco regions	Higher than in La Laguna

Source: Author's elaboration of data from Tables 6.1, 6.2, 6.5 and 6.6, which gives the number of the policies for the ST and LT rows.

For the short term, development policies (2, 4, 5, 6, 7, 8, 9, 10, 13) are the most important for Los Altos and Tabasco. For instance, No. 4, 'Developing dairy supporting industries and services (e.g. production of semen, heifers, milking and chilling systems, dairy technologies, etc.)' entails the collaboration of several partners to assess the different business opportunities available, since the market size might already be attractive. For instance, although INIFAP Veracruz and Nestlé developed technologies for the production and distribution of semen for crossbreeds, the start-up of a production facility requires entrepreneurs with economic resources. Attracting resources from the federal government (i.e. Alianza para el Campo), CONACYT, FIRA and other commercial banks such as BANORTE seems to be a viable strategy.[316] The same strategy would apply to other projects that could complement a more advanced agribusiness structure, similar to what Denmark and Sweden have done for the export of agriculture and forestry products with higher value since the late 19th century (Edquist and Lundvall 1993).

In relation to No. 13, ‘Searching the factors for sustainability’, it could be that creating an effective means to reduce unfair trade as soon as possible (particularly in the light of increased pressure in 2008) would be a major challenge for the policy makers. It could be that the most important trade changes have already taken place and the expected trend is increased imports of NFDM, milk preparations and dairy products. However, it is still possible that due to changes in land tenure, large investors could be attracted to set up specialised milk production units, either in association with established dairy farmers or by acquiring their own units of production. This might increase competition especially in evolving regions (e.g. Los Altos and Tabasco) and further exclude small farmers if their profitability and competitiveness remain low.

No. 7, ‘Developing infrastructure for standardisation of dairy production (e.g. legitimating government organisations for industrial development and testing labs for dairy imports and industrial control, COFOCALEC, PROFECO, etc.)’ is the policy at the core of industrial progress. The lack of agreement at a macro level, among the national organisations for standards for milk and dairy production, impedes any clear direction of underlying research and investment, a failure of the system and the CSPBL[317] to get coordination and alignment of regional actors and to influence the decision-making processes at a national level. Since there is no legal framework, there

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[316] LICONSA had already produced embryos of specialised dairy cows and semen of F1 cows in its development programme that ended in 1997 (Sánchez Aldana and Ramírez Castañeda 1999) (see Appendix I, section 1.4).

[317] CSPBL is a social technology and an institution (according to Nelson and Nelson 2002), which has not yet had a positive impact on the system. An example of a dysfunction in the direction of search is policy recommendation No. 3.

are no incentives to produce high quality milk and dairy products from certified dairy farmers and firms. Therefore, small dairy farmers and artisan dairy processors may find it more difficult to access national and foreign markets.

No. 8, ‘Developing infrastructure for IPR laws, PDO status for regional products, socio-economic and environmental guidelines for regional development and legitimating the involved processes’ is similar to No. 7. Weaknesses in these areas may delay the progress of tropical and temperate regions in particular. Therefore, agreement and resources to support these policy areas might involve regional actors, mainly small dairy processors, not involved in the CSPBL, and their participation would be a milestone in the upgrading of the regions. The formation of the CSPBL as a coordination mechanism *to drive direction of search* in the MDS has lacked the real participation of dairy firms. Therefore, the vision and strategies of regional systems are unclear, i.e. what the actors in the system want and how to obtain it. The result is that there are regional disparities and lobbying by powerful actors (dairy firms and farmers) dominates, and there are no well-developed government strategies to mitigate the damage to vulnerable parties, which may explain their poor participation in the CSPBL.

No. 12, ‘Fitting the incentive systems for researchers to promote user-producer linkages (i.e. incentives from the SNI)’ is a policy that perhaps could be re-formulated to provide regional incentives. However, support to create absorptive capacity among specialised and non-specialised labour (No. 2) must accompany this policy. If farmers remain at a low level among users, as is currently the case for many small farmers, their expected impact on the overall system might be low.

La Laguna and the arid regions in general are growing faster than other regions. Thus, No. 11, ‘Developing the infrastructure for sustainable agriculture’ (although important for all regions) is crucial to avoid problems of water availability and No. 3 would be complementary to deal with choices among technologies and organisation of actors.

Policies to create endogenous technologies and accelerate their diffusion are included in No.1. What is important is how to generate the economic resources to support them. For instance, in La Laguna, PIAL projects have produced some positive results. Therefore, increasing the mix of resources (public and private) would be important for the development of technologies to support the organisation of dairy development, which might include a technological centre for specialised systems. Some of the technologies that might be considered would include technologies to improve the use and recycling of water, to avoid over-exploitation of subterranean water, and industrialisation and transformation of manure to avoid ecological problems.

Los Altos has several actors and institutions that should be considered for policy development in specific areas, such as speeding up the implementation of features of the Holstein model without threatening small farmers and environmental conditions.

The set-ups of COFOCALEC for standardisation of the regional dairy industry and CIATEJ for development of dairy technologies might facilitate national formation of organisations and institutions aimed at national standardisation and the expansion of CIATEJ to become a dairy technology centre.

Finally, more account should be taken of remittances from labour in the US, which might explain the investment in dairy, but not capabilities development, since there is no clear-cut increase in the productivity of the herd; instead, it seems more related to a growth in the size of the herd (i.e. organic growth).

In Tabasco, there is a need to develop a much more structured set of general policies. If the focus is on policy areas 6, 7 and 10, some short-term achievements might be expected since there are organisations (e.g. FIRA, Fundación Tabasco and Fundación Produce Tabasco) and networks of learning (e.g. the network of artisan cheese processors and Fundación Tabasco and the DEPAI and GGAVATT groups) already in place, and efforts and resources have been allocated. Therefore, to provide more resources to support these organisations and networks might improve the performance of the region. However, it is important to establish whether milk production in tropical regions is sustainable and whether artisan cheese production is a better option for tropical dairy.

A general principle of functionality vs. dysfunctionality in any system is that all the actors should have a common purpose. If they have different purposes this could create sub-systems whose interactions would need to be constructive and may need to be mediated by processes of competition or rivalry that are transparent, resulting in the selection of technologies and markets. The existence of a mix of development areas with homogeneous objectives and areas of development with rival (but transparent) objectives is relevant for the general theory of functions in systems as an explanation and validation of what is happening in the dairy regions and what should be done to improve them.

As a general policy recommendation, and using a top-down approach, it is not enough to prescribe self-sufficiency or food security as the aim of policy making for the MDS. Nor is it sufficient for the CSPBL to act as a steering committee attempting to set up bases for the development of national policies. What are needed are coherent regional policies that create regional projects to accelerate the production of milk and dairy products in selected regions. However, this has implications. In order to do so, first, it is necessary to assess capabilities accumulated in different regions to provide the most adequate input for the selection of a portfolio of development projects. In this way, a better balance of policies between development, regulation and equity would involve appropriate blending or assemblages of capabilities in policy making and implementation (von Tunzelmann 2009a, p 24). This is very important for the elimination of the constraints that lead to dysfunctions in the regions.

6.6 Summary

This cross-case analysis has shown that regional dairy systems have created and evolved their capabilities, institutions and networks to serve, in coherent or less coherent ways (i.e. different mixes of functional/dysfunctional patterns) with consequential economic outcomes. The situation of accumulated regional capabilities already developed before 1994, i.e. a path-dependent process, influenced the extent of the evolution of capabilities following the signing of NAFTA. Therefore, disparity in the evolution of capabilities in the regions was to be expected.

La Laguna’s dairy farmers and firms increased milk production and integrated the value chain for high quality chilled milk, which allowed Lala and Chilchota to produce a higher variety of dairy products and to expand dairy production (i.e. Lala) to other regions and markets. La Laguna attracted other large dairy processors to buy milk, because of the availability of high quality fresh milk. Los Altos followed La Laguna's strategy, increasingly implementing specialised milk production systems, and integrated networks of high quality chilled milk. This contributed to the expansion of Lechera Guadalajara and Nestlé and attracted other large dairy firms to set up in the regions (i.e. Sigma Alimentos, Parmalat, and LICONSA). Nevertheless, the trade in non-chilled milk and the production of unpasteurised cheese were still important in the dairy regions. In Tabasco, although the region has developed capabilities, they have not achieved the extent of La Laguna and Los Altos.

Regional dairy development capabilities can be explained by tracking the extent and kind of capabilities that have changed in the effort to achieve better performance, regardless of the initial state. Specifically in the Tabasco region, new capabilities were required in order to improve milk production. Dairy farmers and dairy processors had to make significant and multiple changes in a more complex and not always coherent way (e.g. creating the crossbred cows, building the milking and chilling infrastructures on farms, developing the hygiene practices on farms, integrating with dairy processors and so on) to produce and deliver high quality milk. The cause-effect relationship is confused because the cognitive structures in the system may not have been formed and the rates of learning diminished as a result. One implication of this is that much higher investment in the long-term development of capabilities was required than what was provided.[318] This could also apply to Los Altos; the infrastructure for milking and chilling systems was more advanced than in Tabasco, but less developed than in La Laguna in 1994. Similarly, the development of capabilities to expand the markets from regional to national can be explained by the investment made by the large firms in the development of their capabilities in La Laguna and Los Altos compared with Tabasco, which is still a regional industry.

The analysis shows that Los Altos and Tabasco have had to overcome bigger challenges in creating capabilities for economic sustainability than La Laguna, because of the larger numbers of small dairy farmers needing to be integrated, the heterogeneity of their milk production systems and the dispersion of the units of production (in the case of Tabasco). Nevertheless, in the case of Tabasco, it is clear that alternatives to a

[318] This is clearly explained for firms (Teece, Pisano et al. 1997).

modernisation process can coexist in the MDS. However, what is unclear is whether production of milk and dairy products in Tabasco would be sustainable in the long term and what would be the cost of achieving better performance (i.e. specialisation of the dual-purpose systems into milk production, which seems to be occurring based on the rate of growth of milk production vs. beef production, see Figure 6.1).

By using the concept and its analytical framework, it was possible to identify the changes of intra and inter organisational capabilities of the farmers and dairy processors, which contributed to functions/dysfunctions in the regions. This analysis was used to develop fourteen policy areas aimed at supporting the economic sustainability of the dairy regions. In so doing, it is possible to develop specific policies directed to the development of individual actors' capabilities (i.e. intra organisational capabilities) and/or regional (or system) (inter organisational capabilities) to also affect institutions.

Chapter 7 will revisit the research questions, together with the theoretical implications and contributions, the limitations of this research and provide conclusions and areas of further research.

Chapter 7. Research questions revisited, theoretical contributions and emerging research areas

This chapter reviews the research questions of capabilities' evolution in regions, draws theoretical contributions and provides some conclusions and emerging research areas based on the previous chapters. It has five sections. Section 7.1 revisits the research questions in the light of the cross-case analysis in Chapter 6. It has two subsections; the first discusses the capabilities building processes and the main learning mechanisms for capabilities building. The second discusses the factors that impede capabilities building processes. Section 7.2 discusses the theoretical implications and contribution of this research. Section 7.3 suggests some limitations of this research and emerging issues for future research. Section 7.4 draws some conclusions from the theoretical and empirical discussion of capabilities building processes at different levels of aggregation. Finally, section 7.5 summarises the chapter.

7.1 Revisiting the research questions

This section revisits the research questions and summarises the evidence from the preceding chapters to answer them. First, we asked:

How have regional capabilities (intra and inter organisational capabilities) of dairy firms and their milk suppliers changed as a result of interactions with other regional actors (e.g. government organisations, research organisations, MNCs, universities, etc.) following NAFTA? Have these regional capabilities been responsible for improving the productivity and competitiveness of the dairy regions?

Dairy farmers and dairy processors in all regions have developed and accumulated intra and inter organisational capabilities since NAFTA. Dairy farmers increasingly implemented changes in technological components following the intensive milk production system and dairy producers changed dairy production and improved their processes and products, producing new dairy products according to international practices set up by worldwide leaders of milk and dairy production.

The fact that dairy producers demanded increasingly higher volumes of high quality chilled milk for industrialisation triggered and accelerated changes in farm capabilities. The fact that higher volumes of high quality chilled milk were produced supported the development of improved and new dairy production.

The accumulation of milk and dairy production capabilities was the result of changes in routines and practices of herd management (i.e. animal health, reproduction and nutrition) in dairy farming to improve hygiene practices in milking and the increasing use of mechanical milking and chilling systems, agricultural practices for feedstock production and improving the logistics capabilities to integrate the value chain. The overall result was improvements in productivity (litres per cow per day) and milk quality. An increase in the volume of high quality chilled milk led dairy producers increasingly to change their dairy production by integrating new dairy technologies.

It is clear that NAFTA was a disruptive factor that pressured dairy farmers and dairy producers in dairy regions to respond to the globalisation process. However, they responded to those pressures depending on their understanding and perceptions of the threats and opportunities created by NAFTA on their business, the already accumulated capabilities in their units of production, their economic resources, their absorptive capacities and the stage of different regional actors and institutions. What is clear from this research is that the accumulation of capabilities before NAFTA influenced the evolution of capabilities in the period analysed and had an impact on the productivity and competitiveness of the dairy regions, i.e. path-dependent processes. This is in line with the authors that propose regional capabilities (Cooke 2005; Heidenreich 2005; von Tunzelmann 2009a). However, this research did not conduct in-depth analysis of capabilities before NAFTA. The historical analysis provided some insights into what the situation of the regions was at the time of the negotiations for NAFTA.

Although milk and dairy production is an economic activity dating back to the Spanish Conquest, modernisation processes did not begin with NAFTA, but in the 1950s in La Laguna with the introduction of specialised milk cows and an associated technological package. This happened as a response to the crisis in international cotton prices, which forced the region to adjust to the international market, for which federal government intervention provided the resources to build up a specialised herd and to improve the infrastructure required for feedstock production. Therefore, when NAFTA arrived, La Laguna dairy farmers had already adopted a specialised model for milk production and were better integrated with large dairy processors. Therefore, the region had developed strategic capabilities, which allowed the region to be considered as modern, directed towards being inserted into a globalisation process. The patterns of innovation were different in the other two regions.

The Los Altos region was a more traditional dairy region, although older than La Laguna in milk and dairy production. Just before NAFTA, Los Altos had already increasingly integrated the value chain to commercialise chilled milk with the support of the government and regional firms. However, farming capabilities were disadvantaged compared with La Laguna. After NAFTA, the region increasingly adapted the features of the specialised model for milk production supported, as in La Laguna, mainly by the large dairy firms (i.e. Lala, Alpura, Sigma Alimentos and Nestlé), MNC suppliers of inputs for milk and dairy production, government organisations and financial organisations.

In the tropical region of Tabasco, milk production is a more recent economic activity compared with the other two regions, which started with the development of a dual-purpose system in the 1970s, as an alternative technological system for milk production relying on the complementarities between beef and dairy using crossbreed cows. With NAFTA, the region was at a greater disadvantage than the other two regions. However, the modernising of Tabasco's dairy system had already started to the extent of adaptation of some of the technological components of the specialised milk production model and integration of dairy farmers into commercialisation of chilled milk for industrialisation. However, the process is still evolving at a slower speed than in the other two regions.

Changes in the adoption of the specialised milk production system for dairy farmers in all regions were supported by increasing interactions with dairy processors and suppliers of inputs and services, including government, research and financial organisations, which involved learning processes for capabilities building and accumulation in the regions. It is clear that in all regions, actors' interactions favoured large dairy farmers and firms in the adoption and adaptation of the intensive milk production model. However, support programmes PROCAMPO/Alianza para el Campo failed to develop the infrastructure and support capabilities of small dairy farmers and firms.

Based on current knowledge, the intensive milk production system is the most appropriate to fulfil the needs of dairy producers for higher volumes of high quality chilled milk. La Laguna was the first to adopt the model, which did not immediately spread to the other regions because of a lack of national market integration and difficulties involved in mobilising investment and developing capabilities. The full modernisation of Los Altos is still in transition and Tabasco has been delayed by the heterogeneity of technologies of production, capabilities and economic capacities of large numbers of farmers compared with La Laguna. The underdeveloped capabilities in the Los Altos and Tabasco regions are farmers' technological capabilities (e.g. herd management and best practices for dairy farming) and organisational capabilities for reaching adequate levels of high quality chilled milk and for integrating networks for commercialisation of chilled milk. The most likely path to sustainability for the Tabasco and Los Altos regions is specialisation in milk production over beef, involving 'more specialised configurations' of the technological components for milk production[319] in order to achieve higher productivity.

This could imply that in 20-30 years' time, there will be a single technological-organisational configuration for milk production for most of the dairy regions, or that Los Altos and Tabasco will continue to produce milk for as long as they can exploit the specific advantages within their systems. Thus, heterogeneity among the regions might refer to persistent differences in capabilities in artificial feeding when natural grazing (planted pasture) is specialised for the specific features of the areas (i.e. Los Altos with a more temperate climate and Tabasco with a more tropical climate), and capabilities for improving feedstock production, e.g. the introduction of grains and other supplements, which are becoming the standard for animal nutrition to improve herd productivity.

[319] This specialisation implies the generalised use of technological routines and capabilities (e.g. improved crossbreeds, feedstock systems, professional and specialised labour, improvements to milking and chilling systems, etc.) and does not necessarily mean the large herds found in La Laguna. Researchers and specialists in milk production suggest that for Los Altos (Cervantes Escoto, Santoyo Cortés et al. 2001; Falcón Estrada 2005; Soltero Gardea 2005) and Tabasco (Muñoz Rodríguez, García Muñiz, et al. 2003) a minimum of 25 cows in production would be an economic scale for those regions.

This research shows the regional capabilities accumulated until 2004-2005 and formulates 14 regional policies aimed at the long-term growth of the regions, which can be summarised as follows.

The strategic capabilities accumulated in the La Laguna dairy region show that regional expansion has already started in other regions for milk collection and exporting dairy products. In Los Alto and Tabasco, a large amount of resources for technology transfer and training programmes to create capabilities in herd management, milking and milk conservation and logistics must be taken into account for future regional policies in Los Altos and Tabasco to attend to the large number of small dairy farmers and firms, which require an increase in the tacit knowledge embedded in their farming practices in order to improve capabilities and their economic performance and eventually to be fully integrated into the value chain as has already occurred in La Laguna. There is also a need for resources to build up the infrastructure (e.g. chilling tanks, mechanical milking, etc.) to introduce ‘more specialised configurations’ and practices (e.g. artificial insemination, farm management, etc.) for milk production. An alternative technological trajectory would involve greater real heterogeneity, including the possibility of developing a ‘formal’ industry for the production of unpasteurised artisan cheeses. This industry is already under way in both Tabasco (Dirección Fomento Económico y Turístico de Tenosique Tabasco 2008) and Los Altos. Whether this is an economically sustainable option is hard to assess, but if it were to prove so, it could be a way of improving rural development.

Artisan cheese production in Los Altos and Tabasco might evolve to the extent that artisan cheese producers integrate with large retailers. For these processes to happen, developing infrastructure for standardisation processes for milk and dairy production as well as PDO are essential because it is expected that large supermarkets will continue to lead and influence commercialisation in the future (Reardon, Codron et al. 1999; Reardon and Berdegué 2002; Reardon, Timmer et al. 2003). Furthermore, increased scales of production and commercialisation will be required, which will also include organisational capabilities needed to attract the necessary investment to increase production capacity and/or to integrate artisan cheese producers to reach a scale adequate for making a profit. However, for these changes to occur will require government intervention to improve the regional capabilities specific to Los Altos and

Tabasco. Another option would be a takeover by large dairy firms (e.g. Lala, Chilchota and Sigma Alimentos), which are more capable of implementing the strategies to use those commercialisation channels.

One of the most important policies for all the regions is to address research for developing the capabilities for making milk production ecologically sustainable in the long term, given the problems already created in the regions (i.e. water supply problems, contamination of water and air and land erosion from intensive grazing). This might require the creation of strong institutions and regional development programmes.

7.1.1 Capabilities building processes and learning mechanisms

This research has identified and provided evidence of changes in main sector-specific regional capabilities in the three regions by using the regional capabilities concept and the analytical framework. The accumulation of regional capabilities is the result of different learning processes within firms and regions, which affected: a) the creation of multiple assemblages of organisational routines as already discussed in the literature of capabilities building (e.g., Levinthal 2000; Narduzzo, Rocco et al. 2002); b) changes in the sets of traditional routines in line with von Tunzelmann (2009a, p 16); and c) changes in actors' behaviour, which explain the agency of individuals to change organisational routines, as Feldman (2000) and Nelson and Winter (1982) pointed out from rigid to processes for change of individuals with different learning styles.[320] However, the delay in these changes, in addition to a lack of infrastructure and absorptive capacity of farmers and firms, could have been the result of resistance of individuals to change their practices because of cultural features of actors in the regions (e.g. traditional short-term vision and management style and lack of trust among actors) (see also subsection 7.1.3).

These changes of capabilities are inferred at the meso level, but many of them have occurred at the micro level, i.e. changes in technological and organisational capabilities of individual firms, as the cases have shown. For instance, farmers increasingly improved and changed technological components, routines and practices within their

[320] These individual learning styles were not identified in this research, but they are well studied in the literature of learning. See, for instance, Bessant and Tsekouras (2001).

units of production supported by different actors at different times. From these changes, we infer that collective learning and capabilities development processes occurred at the micro level. To establish the plausibility of causation we assemble evidence about the collective activities/processes/mechanisms of dairy farmers and firms and other actors in the system, which produce and exchange types of knowledge, technologies and resources. Specifically, we refer to the activities/processes/mechanisms of the DEPAI and GGAVATT groups, technical groups from dairy firms to support dairy farms and the incentives of the large dairy firms, etc. These convergences of knowledge, technologies and resources eventually affected one or several of the technological components of the systems of productions, their routines and procedures and eventually changed, improved and/or created individual actors' and regional capabilities.

The accumulation of intra organisational capabilities (i.e. technological and organisational capabilities) and inter organisational capabilities in the regions depended on the degree of effectiveness, coordination, coherence and alignment of the regional organisational interactions (see Tables 6.3a, 6.3.b, 6.4 and 6.5), which confirms von Tunzelmann's suggestion (2009a, pp 15 and 16) that 'The extent to which interactive capabilities of producers are dynamic depends upon the extent to which the resources or products are not only attuned to the capabilities of their suppliers or consumers, but are so when the latter capabilities are constantly undergoing change' and in order for 'a cluster to progress its capabilities need to be interactive and dynamic'.

The main sector-specific regional capabilities identified in this research are summarised below.

Table 7.1 Main sector-specific regional capabilities from three dairy regions

Intra organisational capabilities	Inter organisational capabilities
Technological capabilities Herd management capabilities Dairy farming capabilities Agricultural capabilities for production of grains, silage and grazing to improve feedstock production Firms' production, R&D and engineering capabilities	Milk and dairy production capabilities Research capabilities for milk production Technology transfer capabilities Animal disease control capabilities Farm design and operational capabilities Capabilities to develop PDO for the production of regional cheeses Alliance-making and acquisition capabilities Service capabilities for standardisation of milk, dairy products and dairy facilities Relational capabilities for developing networks of high quality chilled milk, networks of inputs for agriculture and dairy production and networks to provide financial resources
Organisational capabilities Firm management, operations, financial marketing and branding capabilities Dairy firms' service capabilities for improving quality of milk	

Source: Author's elaboration from Table 6.3a, 6.3.b, 6.4 and 6.5.

Whereas the intra organisational capabilities are mainly milk production and commercialisation capabilities and dairy processing and market development capabilities, inter organisational capabilities constitute mainly regional dairy development capabilities, as proposed in Chapter 4 (see also Table 4.2).

It is important to note that this proposal of capabilities can apply to other systems/regions, although the sources of knowledge and technologies must be carefully analysed for each sector.

Three important factors that characterise the learning processes and mechanisms carried out collectively by several actors to change routines and capabilities are: a) intentionality to change practices, routines, procedures and processes within firms; b) involvement of human and economic resources; and c) systemic processes of interaction and negotiation among individuals for knowledge creation and exchange to set up new sets of routines, which eventually become the improved and new capabilities. Some of this knowledge creation and exchange was internal (micro) to the firms and other external to the firm but mostly regional (meso level) as expected in the creation and exchange of tacit knowledge.

The five main mechanisms that have created learning processes (i.e. creation and exchange of tacit and codified knowledge) to respond to how dairy farmers changed their capabilities supported by other organisations are summarised as follows:

1 *Technical support groups* (i.e. veterinarians and agronomists) from large dairy firms dedicated to help dairy farmers solve problems about how to improve farming practices and to improve farm profitability (the case of Nestlé). Veterinarians and agronomists from large firms worked together with farmers to solve mainly technical problems such as milking practices, cleaning, use of insemination, etc. To do so, they provided control systems and laboratory services to verify milk quality and provide feedback to farmers. Dairy firms also developed other economic incentives and rewards for farmers regarding the quality of milk delivered. This technical support in many cases was not free for farmers, except in some cases in La Laguna. Regarding direct economic support, dairy firms acted as para-financieras and/or providing cheap loans to farmers to build up infrastructure for chilling systems and mechanical milking. In this way, they contributed to creating the technological platform to produce high quality chilled milk (e.g. Lala, Sigma Alimentos and Lechera Guadalajara).

Nestlé has also supported inter organisational capabilities in the tropical regions for research when collaborating with INIFAP La Posta in Veracruz to produce the crossbreed cows and semen for dual-purpose systems, which is the most suitable and increasingly more used crossbreeding type for the tropical regions. The fact that the crossbred cows have shown a certain degree of heterosis is an example of the endogenous capabilities developed for tropical areas. However, further research must be done to consolidate the dual-purpose model in terms of scale of production for industrial production. Although there is no measure of the impact of technical support groups, it could be said that it might have been the most important interactions among farmers and dairy processors that triggered the learning processes within farms in all the regions.

2 DEPAI and GGAVATT technology transfer programmes designed by INIFAP researchers and technically delivered by SAGARPA regional officers together with dairy farmers' associations and regional Fundaciones Produce. INIFAP researchers in each of the studied regions identified dairy farmers' needs and carried out regional research to improve specific technological components of the specialised milk production model. INIFAP Matamoros specialised in the production of feedstock, which is the most important factor affecting the cows' milk productivity in intensive milk production systems, looking at ways of decreasing production costs. INIFAP Jalisco specialised in expanding what is called best practices for milk production in family farms; and INIFAP Tabasco, in Huimanguillo, specialised in research into intensive grazing systems and best practices for milk production to improve nutrition and increase cows' milk productivity. For delivery of the technology transfer, INIFAP regional research centres, universities and agricultural officers trained and certified DEPAI agriculture extension agents in GGAVATT methodology. Agriculture extension agents are responsible for carrying out technology transfer programmes (see subsection 2.4.5), which focus on solving problems within farms. Some of the mechanisms that triggered changes in farmers' routines and capabilities are: a) collective learning by sharing experiences among group members to create endogenous knowledge; b) imitating best practices from advanced farmers; c) codifying information that helps to control the technological processes within farms; d) multiple feedback loops for learning, from the researchers and extension agents to the group members and vice versa; e) speeding up the decision-making processes to implement changes on farms; f) self-driven developing processes supported by shared values (e.g. trust, help, imitating); and g) committing and delivering results to encourage other group members to imitate and improve their farms' practices (Román Ponce, Bueno Díaz et al. 2001; Román Ponce 2005). DEPAI and GGAVATT groups have been operating and assessed since 1999 and 1997 respectively (INIFAP-DGIP 2004). However, these technology transfer programmes need to be updated to include the milk commercialisation stage.

3 *State Fundaciones Produce development programme* designed by SAGARPA and private farmers to improve the development of agricultural production. In the case of milk production, SAGARPA regional officers with private farmers identified farmers' needs and INIFAP centres carried out research to fit those needs. In La Laguna, PIAL projects were designed to improve animal feedstock production and farm management (e.g. alfalfa and grain production, reduction of water in alfafa production, recycling water on farms) focused on the intensive milk production system. The PIAL projects operated with the collaboration of researchers from INIFAP Matamoros and selected farmers, who worked together for at least one year carrying out parallel tests in experimental areas of INIFAP and on farm sites. Researchers and farmers assessed the results and shared them with the farming community every year at a demonstration field day, for which technical reports were generated and distributed among farmers. These practices have taken place since 2001. In the case of Los Altos, FUNPROJAL collaborated to implement DEPAI technology transfer programmes and with a complex network of agents (see section 5.2.2), it has worked to improve the technical practices and managerial capabilities of farmers. In the case of Tabasco, Fundación Produce Tabasco developed research projects with INIFAP Tabasco, in Huimanguillo, aimed at developing and diffusing technologies among farmers for intensive grazing systems to improve animal nutrition and milk productivity. It has also collaborated with SEDAFOP to implement GGAVATT groups. Additionally, SEDAFOP has had a dairy development programme since 2000 (i.e. PROFELET), which focused on supporting farmers to re-populate dual-purpose herds, to develop prairies for intensive grazing and to establish the infrastructure for mechanical milking and chilling tanks on farms.

4 The main *training programmes* focused on improving milk production practices were those organised by DECyREMA in Tabasco and by ITESM La Laguna. The DECyREMA training programme has been carried out since 2002 to develop the skills of farmers ‘in situ’ for improving their technological capabilities for milk production. SEDAFOP officers together with farmers’ associations identified the training needs of farmers and the training courses were ‘tailor-made’ by CECAREM, which also implemented and assessed the achievements. Participating farmers showed some improvements in productivity and profitability due to changes in their practices (SEDAFOP 2003; SEDAFOP 2004). The dysfunctional side of the programme is that only a small number of farmers have taken part (see Table S5.14). In the case of the training programmes organised by ITESM La Laguna since 2000, they were designed specifically to develop managerial capabilities among owners of farms, ‘mayordomos’ and agricultural government officers in the region. These programmes seemed to have contributed to the herd management capabilities within farms and of government officers attending to farmers’ needs.

5 *Technical training by suppliers of inputs for agriculture and milk production and dairy exhibitions* in the regions. These networks of suppliers have been improved and are achieving major impact in all the regions. Additionally, ENGALEC in La Laguna, annually since 1992, CIGAL in Jalisco, annually since 1984 and Foro Regional de Lechería Tropical, biennially since 2000, have strengthened these regional networks for learning among farmers and suppliers of inputs and services for milk production. They bring together national and international specialists in different disciplines to deliver seminars and workshops (e.g. Fundaciones Produce, regional INIFAP research centres) to farmers and other agents involved in milk production. They have had an important impact on the modernisation processes of the regions (e.g. acquisition of new equipment and development of new processes following the technological components of the specialised milk production system) and have played a major role for capabilities development because of the localised interactions (i.e. user-producer interactions) for learning.

LICONSA’s role in supporting capabilities building of dairy farmers to produce high quality chilled milk has had an ambiguous impact (see Appendix I, section 1.4) because of its contradictory policy, which started with a development programme ending in

1997, and more recently buying lower quality milk at a higher price compared with other dairy producers (see section 2.3). The latter policy has distorted the market for fresh milk in Los Altos and has not encouraged farmers to improve their practices for higher quality production or to set up chilling systems to preserve the milk quality. However, it has developed capabilities for producing low cost milk and nutritional dairy products for the low-income population, and has improved its industrial processes, including the logistics for milk collection and distribution without using chilled tanks. These practices, although they do not follow the standards for best practices in milk and dairy production set up for large and medium-sized dairy firms, they might be recognised as alternative ways of dairy production. Nevertheless, further research on them is needed, which may influence the future standards of the regions.

For dairy production, the most important mechanisms that have triggered learning for improving capabilities within firms are:

1. *Development and strengthening of R&D activities by* large and medium-sized firms, e.g. Lala, Sigma Alimentos and Lechera Guadalajara, strengthened their R&D department recruiting food and dairy technologists and investing in laboratories and joint projects to develop new products and processes.
2. *Alliances of these large dairy producers with foreign firms for dairy production* (e.g. Lala and Sigma Alimentos) have also contributed to improve their technological capabilities. In the case of Lala, a MNC assisted the firm to create an inter organisational process to standardise the dairy production, i.e. total quality management capabilities, in all its facilities acquired to expand its production into national and international markets. Sigma Alimentos received economic support from CONACYT to develop dairy production. Lechera Guadalajara, Alimentos La Concordia and Ultralácteos mainly relied on the technical advice of MNC suppliers of machinery and equipment, food additives and dairy inputs set up in Mexico.

These mechanisms seemed to be the most effective for creating learning processes and capabilities development in dairy production because dairy firms selected suppliers and engaged in collaborative projects, which involved project management intra organisational capabilities and strengthening of absorptive capacity of the firms. It is clear that these capabilities became strategic in large dairy firms (e.g. Lala, Lechera Guadalajara and Sigma Alimentos) when they have alliances with MNC suppliers of technologies because of the large amount of resources involved in the evolution of these capabilities.

A summary of some of the learning mechanisms for both milk and dairy production that respond how regional capabilities evolved is presented in Table 7.2. These mechanisms are elaborated based on the 'stylised' ones for firms proposed by Zollo and Winter (2002) (i.e. knowledge accumulation, knowledge articulation and knowledge codification) and for regions proposed by von Tunzelmann (2009) (i.e. learning by doing, learning by using, learning by training and R&D).

Table 7.2 Some learning mechanisms for regional capabilities building

	Learning mechanisms			
Mechanisms for capabilities building	**Sharing and comparing experience**	**Collaborative problem solving**	**Information and knowledge dissemination and codification**	**Imitation of best practices**
Technical support groups from dairy producers and suppliers of inputs	Present	Present	Present	Present
Technology transfer programmes	Present	Present	Present	Present
Development programmes	Present	Present	Present	Present
Training programmes	Present		Present	Present
Technical exhibitions	Present		Present	
R&D activities for dairy production	Present	Present	Present	Present
Alliances with foreign suppliers dairy production	Present	Present	Present	Present

Source: Author's elaboration from the analysis in subsections 5.1.3, 5.2.3 and 5.3.3.

It is important to note that in most of the cases a) external sources of knowledge for firms were present as regional capabilities proposed (Cooke 2005; von Tunzelmann 2009a); b) co-evolving learning processes took place as the RIS literature has already addressed for the production and exchange of tacit and codified knowledge (e.g., Maskell and Malmberg 1999; Gertler 2001; Gertler 2003; Asheim and Coenen 2005; Asheim and Gertler 2005; Asheim and Coenen 2006); and c) learning processes are not automatic, they take time to affect procedures and routines and to form new assemblages of routines to change capabilities (as the literature has already addressed), which depend on the absorptive capacities of firms and the complementarities of resources of the firms (e.g., Dosi, Nelson et al. 2000; Zollo and Winter 2002; Winter 2003; Helfat, Finkelstein et al. 2007; von Tunzelmann 2009a); also as a result of the resistance of the individuals, their negotiation processes within their organisations to set up the new sets of routines and with other organisations (e.g. the processes to achieve the demanded standards for the quality of milk).

One of the main problems in tracking and assessing the achievements of these learning mechanisms, e.g. technology transfer and training programmes for capabilities building, is their long-term duration (from 2 to 5 years) and the inability of current instruments to capture their direct contribution to capabilities building and economic performance.[321] However, there was consensus among the interviewees that these mechanisms have achieved a degree of success, which might be associated to changes in regional capabilities and the economic performance of the regions (see Tables 6.1, 6.3a, 6.3b, 6.4 and 6.5). As mentioned before, some of the evidence came from the PIAL projects (Ekboir 2005; Ekboir, Dutrénit et al. 2006) and ITESM La Laguna training programmes (Aguilar Valdés 2005) in La Laguna; some GGAVATT and DEPAI groups in Los altos and Tabasco; and the DCyREMA training programme in Tabasco (Abreu Vela 2005; Pérez Burgos 2005; Reynoso Campos 2005; Ruíz Arriaga 2005; Valencia Zarazúa 2005).

Two important dysfunctions for developing capabilities are: 1) the limited resources of the PROCAMPO/Alianza para el Campo programme to train agriculture extension agents for technology transfer and to set up the platform infrastructure for chilling milk and mechanical milking. The reason was that PROCAMPO/Alianza para el Campo significantly reduced its budget (-2.13% during the period 1995-2004) (see Table A1 in Appendix I) (Alvarez Macías 2005; Arellano Leaño 2005; Mateos Payro 2005). Additionally, PROCAMPO/Alianza para el Campo resources were allocated in a politicised way, to serve only some groups' interests, which happened to be large farmers. This might have contributed to improve their capabilities in updating their equipment and/updating practices, and 2) the lack of incentives for researchers in the SNI to collaborate with farmers. Therefore, in all three regions there have been system

[321] For example, SAGARPA-FAO's assessment tool does not allow comparison of the results of Alianza para el Campo among states because different groups of consultants implement the tool in different ways. Furthermore, the impact of the activities carried out to build capabilities cannot be assessed annually, which is the period for current assessment (Alvarez Macías 2005; Luévano González 2005).

failures over meeting demands for more resources to develop capabilities among small farmers and artisan cheese producers (Alvarez Macías 2005; Cervantes Escoto 2005; Ekboir 2005; Salas Quintanal 2005; Ekboir, Dutrénit et al. 2006). This finding is important because capabilities building processes require resources. If these resources are insufficient the evolution of capabilities will be impeded, even if dairy farmers' and firms' absorptive capacities were high enough to evolve faster.

In summary, from the signing of NAFTA till 2005, the average productivity and competitiveness of the MDS falls short of challenging the US. However, many dairy farmers and few large firms in La Laguna and Los Altos were able to develop strategic and operational regional capabilities for milk and dairy production to get close enough to the barrier to achieving an international competitive position. This has not been the case for Tabasco.

7.1.2 Factors that impeded capabilities building processes

In addition to the regional dysfunctions for capabilities building there were a number of constraints or blocking mechanisms, which prevented the growth of the dairy regions and can respond to the following questions (see also each of the case subsections 5.1.3, 5.2.3 and 5.3.3).

Have other factors impeded the development of regional capabilities? If so, how could future policies strengthen the capabilities building of the regions to support their economic sustainability?

Some of the factors that impeded and constrained the capabilities development can be summarised as follow:

Socio-cultural constraints:

1. The traditional short-term business vision among farmers and dairy producers has not favoured investment in training and upgrading of their knowledge.

2. Family farms and traditional management style, applying to most small farmers, and especially older ones, has impeded the introduction of new technologies and the acquisition of better managerial skills.
3. Lack of trust exists among the regional actors, which is a barrier to effective linkages among them to pursue common aims for long-term projects and speed up the decision-making processes (i.e. misalignment of actors).
4. There is a lack of continuity in agricultural and industrial policies in the regions and the MDS. For instance, efforts have been made in the tropical areas to train professionals in the GGAVATT method, but any benefits may be lost as the result of changes in state governors and reduction of resources (Alvarez Macías 2005).

Economic constraints:

1. The continuing economic crisis of the country might decrease the demand of dairy products. The average low income of the population affects the demand for milk and dairy products, since income elasticity is high (Hernández Laos and del Valle Rivera 2000).

Technical constraints:

1. BSE in the US and Canada impeded the imports of replacement heifers in the period from late 2003 to late 2006. This could threaten milk production in the future; therefore, it is imperative to find alternative sources for heifers.

Education constraints:

1. There is a poor level of basic education in agriculture especially in the rural areas. This is an important constraint to increasing the productivity of small dairy farmers (i.e. lack of absorptive capacity).

The elimination of most of these factors requires a higher level of agreement among national actors in the sector to create new arrangements, networks and institutions. For instance, in order to improve rural education, SAGARPA and Education Secretariat should agree to upgrade rural education programmes and to provide continuity for the training programmes to improve the absorptive capacity of farmers. However, whether the capabilities accumulated can support the sustainability of the small farmers in Los Altos and Tabasco dairy regions in the long term becomes the centre of the discussion. When the NAFTA was negotiated, the tropical regions and small farmers in all regions had clear disadvantages compared to medium-sized and large farmers in the arid and temperate regions (and the US dairy system), which led to an agreement for a 15-year delay to dismantle tariffs. Therefore, NAFTA opened up the Mexican market to direct competition from US producers of NFDM and dairy products in the La Laguna region where productivity was approaching that of US producers in milk production. It also opened up the Mexican market to FDI, which could supplant domestic dairy firms and provide a structure that would organise dairy farmers into a sustainable configuration, but this had not occurred at the time of the fieldwork.

This research provides evidence that the productivity and competitiveness of the dairy regions have increased, albeit unevenly. The patterns of change in regional capabilities lead to a conclusion that convergence achieves better results in milk production based on intensive milk production and the integration of medium-sized and large farms and firms, regardless of the region. Therefore, the extent of accumulation of capabilities following the specialised milk production system in La Laguna became strategic, because of the inclusion of new knowledge, technologies and resources, leading to the establishment of a competitive advantage for the region[322]. The Los Altos region has accumulated operational capabilities, but it is still in a transformation process. Tabasco has accumulated basic capabilities that mitigate rather than meet the threats prompted by NAFTA and still lags behind the other regions. Many farmers in Los Altos and Tabasco have created ‘local sustainability’, which may not be economically sustainable in the long term, because of the dominant value chain configuration (i.e. large volumes of high quality chilled milk) demanded by the dairy industry. Furthermore, the artisan cheese industry, which does not require chilled milk, may remain too small to provide a viable socio-economic solution for Tabasco and perhaps Los Altos. This does not mean that all artisan cheese producers will be wiped out of the regions, but they will exist only at the margins of large and medium-sized dairy firms, allowing the artisan cheese producers to serve only local markets.

Los Altos may be sustainable in the long term if the region speeds up its transition towards the specialisation system and capabilities building. In the case of Tabasco, the adaptations to a ‘more specialised configuration’ for milk production will require more technological adjustments and capabilities suited to local conditions for a large number

[322] This is in line with von Tunzelmann (2009a, p 17).

of small dairy farms. The core issue is to establish local learning processes to align with the dominant paradigm rather than to expect these processes to align naturally.

This regional perspective of analysing capabilities building, using functions/dysfunctions is an important theoretical contribution in terms of understanding regional systems growth with heterogeneous socio-economic and technological configurations. The heterogeneity in the structure of the Los Altos and Tabasco regions (actors, networks and institutions) and capabilities accumulated have major implications for future innovation (Pavitt 2002; Pavitt 2003), which should focus on:

a) increased demand for specialists and professionals to improve related intra organisational capabilities (e.g. inputs for milk production, logistics and distribution channels, regional products, etc.) in small farms to master related opportunities;
b) large investments to increase technological capabilities and create infrastructure for small dairy farms and artisan cheese producers which involve more general dairy business capabilities to serve local markets with improved quality of dairy products and increasing the profitability of the producers. The basic technological platforms would create the infrastructure to produce high quality chilled milk on farms.[323]
c) large investment to update the technology transfer programmes and to expand the learning networks (e.g. GGAVATT and DEPAI trainers and joint projects to identify local needs to be "translated" into research projects and implemented as local solutions) for small dairy farmers and development of institutions for artisan cheese production, i.e. PDO.

Thus, the heterogeneity and contingent nature of the innovation processes in the regions mean that there is perhaps no 'best practice' in relation to innovation for dairy farms and firms and their organisational and institutional set-ups. Each region should innovate

[323] This proposal does not mean that government organisations have to provide the resources. It suggests that innovative schemes of cooperation and collaboration to attain common goals could be the way to engage and align the shared visions of dairy farmers, dairy firms, and government actors.

based on previous experience and technological trajectories (see also policy recommendations section 6.5).

7.2 Theoretical implications and contributions

The concept of sector-specific regional capabilities and its analytical framework developed in this research have improved the understanding of the dynamics of regional capabilities building in several ways:

a) They provide a systemic explanation as to how the micro processes that constitute capabilities (i.e. organisational routines) evolve into intra and inter organisational capabilities within organisations, as previously proposed by Dosi, Nelson et al. (2000) and Zollo and Winter (2002). This literature also argues that these micro processes are the repositories of a firm's knowledge. From this perspective, it might be that firms and in general other organisations (e.g. universities, research institutes, financial organisations, etc.) in a system/region/industry/country might also be repositories of knowledge. Authors agree that firms change these routines because individuals (agents) carrying out the routines within organisations change procedures and routines (Nelson and Winter 1982; Feldman 2000), and learn when they interact and/or reflect on what they do and/or they are influenced by other external individuals/actors/sources. This means that the individuals within firms change their internal resources and/or bring external resources (e.g. knowledge, practices, artefacts, skills, new people, etc.) to the firm through organisational learning processes (Zollo and Winter 2002) and institutional learning (Lundvall, Johnson et al. 2002; Nelson and Nelson 2002) during formal and informal interactions. These learning processes require integration and coordination among individuals within organisations (management) and among them in a system/region to reduce negotiations for selected routines and capabilities embedded in specific technologies, eventually reducing transaction costs (Dosi, Nelson et al. 2000; Jacobides and Winter 2005). These coordination and integration processes, or social technologies (institutions) using the language of Nelson and Nelson (2002), might support or fail to support the coevolving processes of intra and inter organisational capabilities building, which explain the intrinsic dynamics of a system of innovation from a functional to a less functional and even dysfunctional system for capabilities building. These co-evolutionary processes of capabilities building and economic growth are not explained by neoclassical economics.

b) They integrate the micro and meso levels of regional capabilities, decomposing the systemic actors' interactions, their networks and institutions and analyse the processes that government organisations, suppliers of inputs, research organisations and other non-profit organisations carry out collectively to build up capabilities in dairy firms and dairy producers. Some of these interactions support functions/dysfunctions in regional systems of innovation. This process of identification and qualification of the capabilities using functions could not have been done with a more general assessment of capabilities and provides the specificities for regional policy recommendations, which are discussed in section 6.5 (see also Tables 6.6 and 6.7).

c) They explain the development of 'regional capabilities' in traditional sectors (i.e. agribusiness) with a proposal based on Cooke (2005) and von Tunzelmann (2009a), which helps to better understand the differences in the structure of regions and their capabilities. However, these changes in regional capabilities from the micro level were only observed at the meso level and changes of specific micro processes of firms over time were inferred in the light of specific economic outcomes of the regions.

d) They reveal the importance of the local-local and local-global learning processes, which involve absorptive capacities of the regional actors, and affect the learning curve of the firms and regions (von Tunzelmann 2009). It might be that in high tech sectors and manufacturing industries, the differences in regional capabilities are not as important as those found in agribusiness, where different sizes of firms with different systems of production and sets of capabilities, make it difficult to upgrade them, especially when actors are numerous, small and scattered around in a region.

e) They explain how firms are able to integrate several sources of knowledge and technologies that come from complex networks of suppliers as claimed by von Tunzelmann (2009a) and Malerba (2005). Furthermore, the proposed analytical decomposition of intra organisational capabilities into technological and organisational capabilities differentiates the specificities of the knowledge content embedded in the routines of firms and organisations as previously proposed (e.g. Dutrénit Bielous 1998; Tsekouras 1998; Nelson and Nelson 2002) and was useful when we applied the proposed analytical decomposition at the regional level for several reasons. First, it helps to understand how incremental innovation takes place (Malerba 2005; Markard and Truffer 2008). Second, it makes it possible to link technical innovation to economic performance because empirical studies have already demonstrated it (Lundvall 2005). Third, it helps to clarify that the functioning of any system represents a combination of private and public goods and interests (Lundvall, Johnson et al. 2002), which progress through an evolutionary process (i.e. a blend of new sources of strengths with existing strengths) (von Tunzelmann 2009a, p 17). This is demonstrated in the regions, where patterns of technological appropriation and cumulativeness have been developed as a result of the broader use of technologies and/or adaptation of new artefacts and changes in institutions for incremental innovation in a sector. These changes led also to different patterns of value chain integration for chilled milk. Finally, this distinction helps to understand some dysfunctions in regions (e.g. Tables 5.8, 5.19 and 5.27), when the interactions among the actors were less effective in building up capabilities and fell short of developing learning mechanisms to support numerous small actors in improving their technological components and/or did not help them to achieve the required scale of production. This led to a proposal for specific sets of policies for regional development (see Tables 6.6 and 6.7), either to create specific technological capabilities within farms and/or to organise the learning processes and technology transfer programmes, which is by itself an inter organisational capability of the system/region to create and diffuse knowledge, the most important function of a system of innovation approach. Also, the analytical proposition addressed the need for training programmes to develop some other skills and capabilities, e.g. negotiation, teamwork, leadership and other areas to change organisational behaviour, i.e., to affect capabilities of other organisations as well as firms.

f) They provide the timing perspective, i.e. learning curves (Malerba 1992; von Tunzelmann 2009a), to improve intra and inter organisational capabilities in the region. For instance, a longer time is required for higher numbers of individuals and firms to create absorptive capacity, to overcome resistance to appropriating the knowledge and technologies and to coordinate their production capabilities because single routines and capabilities do not stand alone in firms or in systems, but are usually complementary to others (Levinthal 2000; Narduzzo, Rocco et al 2000). Furthermore, the development of sector-specific regional capabilities requires resources, financial assets (Teece, Pisano et al. 2000) and complementarities to build up infrastructure, to change the behaviour of various actors within organisations in the systems because broader assemblages of capabilities have to be sufficient and coherent for distinct sets of practices in order to achieve specific results (Levinthal 2000). Thus, dysfunctions and constraints for capabilities building can be mitigated by adequate policies to trigger learning processes by providing resources.

g) Understanding functions (and dysfunctions) in systems is also a way of understanding alignment and misalignment of actors in systems and/or coherence and incoherence of multiple actors' interactions for inter and intra organisational learning processes – at the core of capabilities development in any unit of analysis as claimed by von Tunzelmann (2009a). Therefore, explaining how routines, capabilities and functions are related in a system is a way of integrating the micro-meso levels for learning and eventually explaining how systems function. A seven-function approach provides a way or tool to observe specific processes (functions) that are the results of actors' interactions that influence economic growth; but these interactions affect routines and eventually the capabilities of the system. Using this approach, it is possible by comparing regional capabilities evolution and accumulation, to improve policy making directed to capabilities development of firms or eliminate the factors that restrict the processes of capabilities development, including changes in institutions.

h) Finally, the theoretical finding on how routines, capabilities and functions are related by looking at the multiple interactions of actors needs an innovation theory specifically to explain changes in a developing context using a mix of high and low technologies, and to address the need for increasing the availability of complementary resources (e.g. setting up infrastructure, training programmes, economic resources to train technology transfer agents, etc.), which can be created and promoted through designing specific policies and tools.

Although there is an improvement in the understanding of regional capabilities building using the concept of regional capabilities and its analytical framework, there is a need for further research to identify and analyse the capabilities building processes in non-profit organisations and not just in firms. These capabilities should coevolve to fit and enhance the capabilities of firms as von Tunzelmann (2009a) has already pointed out. Furthermore, some of these organisations also need to improve their capabilities to deliver their services (the case of research institutes and private-public organisations to diffuse knowledge) and policy making. This is a very important outcome from this research, since most policies do not emphasise the need for development of the capabilities of those supporting actors, or policy development capabilities which involve a collaborative effort among multiple actors with different aims, inputs for the processes and outputs for which the alignment processes are essential (von Tunzelmann 2009a) and demand changes in the institutions. This might be one reason for systemic failures or problems (Chaminade and Edquist 2005; Chaminade and Edquist 2006) in the development and implementation of policies, which most of the time are top-down decisions and do not take into consideration the bottom-up inputs of the actors affected by the policies.

7.2.1 Contributions

This thesis argues that the evolution of regional capabilities led to incremental innovation due to the increasing incorporation of technologies and creation of new ways of carrying out processes (e.g. integration of value chain and evolution of institutions).

This research contributes to the evolutionary economics literature in three ways:

a) Theoretically: the development of the concept of sector-specific regional capabilities and its analytical framework helps to identify and analyse regional mechanisms supporting the changes in routines and the coevolution[324] of intra and inter organisational capabilities in regions, and support specific functions (clustered processes and mechanisms). This provides some micro foundations on how functions in systems work and provides a dynamic way to explain economic

[324] It changes the perspective of co-location in regional systems of innovation in coevolution (von Tunzelman 2009a, p 16).

changes. However, the concept and its analytical framework have to be further refined in order to make the concept and its analytical framework more comprehensive and to integrate them into innovation theory for developing contexts,

b) Empirically: the application of the analytical framework has yielded findings at the sector-regional (meso) level in agribusiness, a sector that has not been studied before in a developing context. The systematic comparison of the structure of regions (actors, networks and institutions) shows that understanding situated learning through the interactions of the actors, regardless of the technological and structural disparities of the regions (i.e. functions/dysfunctions) provides better explanations of the underlying processes creating capabilities and leading differentiated economic performance between the regions compared with traditional growth theories and economic indicators (e.g. number and size of the firms, CAGR, GDP, productivity of firms, etc.), and

c) Policy making: by better understanding the micro foundation of capabilities and mechanisms that build capabilities, it is possible to improve policy making for regional policies, which should address firms' levels (intra organisational capabilities and systems levels (inter organisational capabilities) and remove the constraints of the regions to develop capabilities. Therefore, 'national policies' (top-down perspective) should be tailored by regional needs taking into account their regional institutions and the investment of resources needed (bottom-up perspective). The emphasis in the development of regional policies rather than national policies is to pursue long-term economic sustainability and competitiveness of regions, which eventually might have an impact in the MDS.

7.3 Limitations of this research, the concept, its analytical framework and emerging research

The sector-specific regional capabilities concept is a complex one, involving the integration of the observation of interactions of multiple units of analysis, firms, networks and institutions in regions. Furthermore, empirically, to distinguish technological from organisational capabilities[325] involves ambiguities because what is

[325] This distinction is not made by Bell (1984) and Bell and Pavitt (1993).

inferred in this research is that these capabilities co-evolve over time and the evidence for this was based upon regional-level observation of farmers and some dairy firms. In principle, a larger project than was undertaken here might be able to integrate micro-level data to examine in greater detail the variance in progress among agents and to better understand the effects of entry and exit of milk producers. The absence of such micro-level data in the cases presented here as well as more generally, however, makes remedying this limitation impractical.

The use of functions in systems presents difficulties in establishing clear cause-effect relationships among the capabilities created and the economic outcomes of the system since intra organisational capabilities are sets/clusters of technological and organisational capabilities that have different levels of routines. They encompass different bodies of knowledge, which coevolve in 'virtuous' or 'vicious' cycles that are not easily distinguishable because of the interdependence of the functions or processes involved (Jacobsson 2005; Jacobsson and Bergek 2006). Furthermore, the participation of each of the actors in specific intra organisational routines is difficult to assess especially when the routines that they are affecting or promoting to change have no clear scope (e.g. developing networks of milk suppliers and developing new practices in milking and chilling on farms). This requires more localised research in individual farms and firms, than that pursued in this research. To conduct such detailed research, however, would require a very substantial data-gathering effort which was deemed infeasible for the research presented here.

Another theoretical limitation of the functional approach as proposed implies that systems might have specific aims or purposes to pursue (Edquist 2005). It is possible to argue that systems' functions coevolve naturally, without specific targets set up in advance, a line of argument that seems to follow general systems theory, which emphasises that the set of roles is tied together with channels of communication (Boulding 1956). On the other hand, it might be that not all the interactions of the actors of the systems are understood fully, but this does not mean that they are independent. Instead, they are interdependent and have certain degrees of coherence or inward orientation – as argued by Edquist (2005, p 199) – or alignment and coordination – as argued by von Tunzelmann (2009a, p 23). Resolving this issue would entail further scrutiny of the functions in similar systems, including observation and analysis of clusters of activities and processes of the actors' political arena (or collective) of action, an empirical research programme that might help to resolve whether coordination processes were emergent or the result of prior consensus formation by concerted action.

Further interpretation is needed to assess functions in a development context, because the framework was not designed for this purpose. For instance, entrepreneurial experimentation in this research does not refer to the reduction of uncertainty to develop experiments for the development of a new technology, as was originally proposed by the authors Bergek and Jacobsson. Instead, entrepreneurial experimentation refers to the processes and efforts carried out by organisations to build up new capabilities and capacities in the regions to develop business complementarities serving the major economic activity of the dairy region, i.e. the production of milk and dairy products. This proposal seems to be more sensible in a development context.

Another difficulty in the analysis of functions and dysfunctions is to disentangle their interdependency (self-reinforcing or interlocking). This was recognised by the authors of the framework (Jacobsson 2005; Jacobsson and Bergek 2006). In this research, different actors perform sets of activities, processes and mechanisms that contribute to the same function (multi-factor functions) and capabilities. In addition, single actors carry out various activities, processes and mechanisms that contribute to several functions (multi-actor functions) and capabilities. Therefore, the analysis becomes complex and has a degree of subjectivity.

In addition, the pattern of dysfunctions has two interconnected elements: first, the existence of missed opportunities in developing or amplifying processes of change related to the accumulation of capabilities; and second, identification of how these missed opportunities were reinforced by a number of constraints. In both elements, non-profit organisations played a prominent role leading to the question of whether these organisations coevolved and changed their intra organisational capabilities to fit users' demands (i.e. dairy farmers and dairy firms) or followed separate paths or trajectories. It is possible that these non-profit organisations (i.e. FIRA, INIFAP and Fundaciones Produce) intended to serve users, but did not have the capabilities to do so and did not find the solutions that could be generalised to all the regions (e.g. water supply and slurry management in La Laguna cannot be applied to other regions), hence the dysfunctional outcomes. Therefore, theoretically and empirically, capabilities building in non-profit organisations are important processes to research in the future. This was not covered in this research, and emerges as an important line of research when assessing and comparing the efficiency and effectiveness of non-profit organisations in supporting firms' capabilities building. This research provides some examples of the training programmes offered by some of these organisations.[326] Nevertheless, it provides only inferential evidence on how these mechanisms improved their capabilities, since the units of analysis for this research were the interactions among dairy farms and firms with other actors in regions from which changes in performance can be assessed.

The problem of assessing capabilities development for non-profit organisations is also complicated compared with firms. For firms, it is relatively easy to identify capabilities and relate them to their economic performance (e.g. profit, positioning in the market, market share, financial balance sheet, etc.). For non-profit organisations, there are no well-developed procedures to assess their capabilities and their relationships with performance, although some attempts have been made (e.g. measuring the allocation of resources of PRACAMPO/Alianza para el CAMPO and FIRA or number of training programmes or trainees). In this research, the systems dysfunctions related to non-profit organisations, although 'perceived', are far from being accounted for by the actors, because in many cases there are multiple actors, activities and processes collectively performed. Furthermore, it should also be noted that the objectives of non-profit organisations have changed (e.g. INIFAP and FIRA, see Appendix I); therefore, it is expected that they might also have changed their procedures and organisational routines and built up their 'dynamic capabilities' in respect of the institutional and economic environment in which the firms can best flourish. The main emphasis might be in dissemination and bottom-up determination of policies. However, rather than top-down vs. bottom-up, there needs to be a productive dialogue between the two (von Tunzelmann 2009a, p 19). These changes may take longer than expected due to the complexities of the internal structure of these organisations and the regional structures, inertias and modes of governances to create inter organisational capabilities, since as was identified by several authors, regions are not entities independent of national

[326] An example was ITESM La Laguna providing training personnel to officers of SAGARPA La Laguna, INIFAP and Financiera Rural (see Table S5.2) to develop managerial skills and capabilities.

governance. Therefore, they would affect recipients and/or users of the organisations' services, whose capabilities development would be consequently delayed.

Understanding of the determinants of growth and/or changing the capabilities in non-profit organisations is a central issue in the discussion on evolution from a dysfunctional to a functional system (i.e. greater coherence and alignment of actors' capabilities in systems). This is an important caveat in the literature on the coevolution of institutions (as social capabilities) and capabilities in non-profit organisations. The logic of the analytical framework requires further understanding of the evolution of institutions as well as the factors that impede their evolution, as already addressed by several authors (Nelson and Nelson 2002; Nelson 2003a; Nelson 2003b; Nelson 2008; von Tunzelmann 2009a).

This research does not include analysis of firms' interactions with distribution channels. It is assumed that for the development of capabilities in the system, these interactions are not as important as the backward interactions with dairy farmers, which is not necessarily the case since the evolution of distribution channels (e.g. supermarkets capabilities, creation of chains of convenience stores, etc.) might have had an impact on the integration of dairy producers and farmers.

The research is also limited in understanding the influence of the evolution of other sectors in the same region. This will require further research into regional governance of the regional systems (Cooke, Uranga et al. 1997; Cooke 2001; Cooke 2003; Cooke 2004; Cooke 2005).

This research does not offer a detailed plan for improving the performance of actors involved in providing the quantity and qualities of the resources required for specific outcomes or specifying the timing of their application. Such a plan would require greater effort to identify specific needs for delivering timely policy advice based on a more complete research foundation (e.g. identification of knowledge, technologies and capabilities needs of firms, government organisations, universities, research institutes, etc.).

This research recognises that policy making also involves capabilities development and such capabilities have not been assessed. The efforts by the CSPBL (see section 2.3 and Appendix I, section 1) are an attempt to foster collaboration and alignment among different actors to do so at a national level. However, to improve performance, different structures and processes might be required to improve the absorptive or other capacities of actors in the system. This might make knowledge diffusion and learning more effective in fitting the needs of actors involved in the development of specific regions (von Tunzelmann 2009; von Tunzelmann 2009a).

Finally, as a result of theoretical contributions and empirics, new research directions are outlined for other agribusinesses in developing countries interested in promoting sector-specific regional capabilities. This regional dimension of capabilities development using functions can also be used to analyse agribusinesses in larger regions, such as milk and dairy production in the European Community. This analysis will provide insights into the differences in capabilities due to different structures and technologies of industries between states with predominantly large herds vs. states with predominantly small herds (e.g. the UK, Germany, the Netherlands and France vs. Greece, Portugal and Austria). It would also be useful in analysing the evolution of policies and institutions that might explain the crises in British dairy farming (Lawrence 2007) and or in analysing the implications of dismantling agriculture subsidies in the developed world.

This research does not investigate the economic and social impact of the displacement of small dairy farmers and firms from their economic activities if more imported NFDM and dairy products are permitted. A further analysis of the impact could justify government intervention to impose taxes on imports of these products. Nevertheless, an additional research question to explore social equity might be: Are the capabilities of small dairy farmers and firms transferable to other economic activities (e.g. agribusiness)? If so, what would be the conditions for these actors to engage in those activities?

This research opens the discussion on the need of a multidisciplinary research in relation to capabilities development, which could include cognitive studies; pedagogy, psychology and anthropology, to explain further how regional culture affect the development of capabilities in certain groups of learners (e.g. farmers and researchers).

7.4 Conclusions

This research demonstrates that sector-specific regional capabilities (i.e. intra and inter organisational capabilities) in dairy regions are the results of complex sets of actors' interactions, the coevolution and accumulation of which move from lower to higher levels of routines into capabilities (see examples in Tables 6.3a, 6.3b, 6.4 and 6.5). These processes can be influenced by blocking mechanisms and constraints, which delay their development and accumulation. The accumulation of intra and inter organisational capabilities for milk and dairy production in the dairy regions enables different responses to pressures from external sources, such as NAFTA. In particular, in La Laguna, value chain integration has entailed progressive improvements of several routines for strategic capabilities (e.g. setting higher standards for chilled milk quality, learning how to improve farming practices, developing the logistics to collect chilled milk including the establishment of the chilling system). These changes resulted in the production of sufficient chilled milk to support industrial large-scale dairy production based on accumulative learning processes. The fact that more high quality chilled milk was produced allowed Lala and Chilchota to develop new and better dairy products, and eventually to expand markets for chilled milk and dairy production.

In Los Altos and Tabasco, the integration of dairy farmers and firms' capabilities was still evolving at the time of this study and the cheese and other dairy products based on unpasteurised milk were alternative ways of industrialisation. In other words, a key institution of the dominant paradigm of high quality chilled milk was not fully established in these dairy regions. Nevertheless, other elements of the dominant technological model for milk production have been evolving as the result of substantial learning processes aimed at intra and inter organisational capabilities improvement among dairy farmers and dairy firms, supported by suppliers of inputs for milk production, research organisations and government agencies.

The systemic and systematic analysis of functions and dysfunctions in regions shows that when individual economic actors are able to advance capabilities, in the case of La Laguna (e.g. Lala and Chilchota and large dairy farmers), support from other actors in the system may trigger improvement in capabilities. In Los Altos and Tabasco, the account offered here of the evolution of capabilities highlights the need for continuing intervention by other actors in the creation of infrastructure and capabilities within farms and their integration into their value chains. Therefore, investing in the mechanisms to develop, acquire and share knowledge, although perceived as important in these regions, needs further collective accountability and alignment of multiple actors because in many cases, small dairy farmers and artisan cheese producers rely on third parties (e.g. government organisations, research institutes, universities, suppliers of technologies) to acquire knowledge and technologies. This top-down approach, characterised also by the paternalist culture, lack of trust and short-term vision of business ingrained in many of the actors in these regions, requires future policies that include instruments to change them in order to speed up the evolution of capabilities.

The analytical framework based on the sector-specific regional capabilities concept developed here has been useful. By using the analytical framework, it has been possible to make a systematic identification and analysis of sets of technological and organisational capabilities, which contribute to functions in the dairy regions, enabling comparison of regional performance, and identifying and highlighting *particular* patterns of growth, although some technological convergence was also found among the regional systems studied.

Linking the functional approach with capabilities approach (i.e. the analytical framework) provides the retrospective and prospective role of policy interventions for capabilities development at the micro and meso levels.

This research further identifies the need to improve our understanding of the development of capabilities by non-profit organisations (not included in this research), which are crucial in supporting the development of capabilities in the dairy regions.

In summary, the analysis of intra and inter organisational capabilities, which contribute to systems' functions, has demonstrated that the regional dairy systems are complex socio-economic and technological systems, where actors, networks and institutions interact in the development of capabilities, which eventually affect their economic performance. Although there have been other studies from several disciplines (e.g. economists, historians, veterinarians, agronomists, sociologists, technologists, etc.) of the changes of the Mexican dairy regions, this research is unique in analysing how actors' (dairy farmers and firms) capabilities collectively evolved over time in the regions. It offers substantial explanations for the differences in regional economic performance (i.e. changes in productivity and competitiveness) in the face of neo-liberal policies. It provides a set of 14 policy recommendations with a transparent and well-defined basis in evidence for the development of future policies to help the regional systems to grow in an economic sustainable way.

This thesis provides evidence that the systemic and systematic analysis of how intra and inter organisational capabilities evolve and support functions in systems might be useful for analysing other systems that involve complex activities for the integration of the suppliers of raw materials and the producers of highly perishable products (e.g. fruit and vegetable production, processing and commercialisation).

By linking intra and inter capabilities to functions using an analytical framework, this research provides some explanations in micro-foundation processes, on how functions work in systems and how they contribute to economic outcomes in regional contexts in developing countries, although the framework of seven functions in systems was not designed for these contexts.

7.5 Summary

Chapter 7 presents the conclusions of the research by revisiting the research questions, and discusses some limitations of this research in the evolution of intra and inter organisational capabilities in dairy regions. It discusses the usefulness of the concept and its analytical framework, which combines dynamic capabilities, RIS, regional capabilities, SIS and functions system approaches, providing elements for the identification, analysis and integration of the micro and meso levels of regional capabilities building processes. The centrality of capabilities to underpin functions in this research is consistent with the discussion of functionality in the innovation system literature (Chaminade and Edquist 2005; Chaminade and Edquist 2006) and specifically, the discussion of innovation system functions (Jacobsson 2005; Jacobsson and Bergek 2006).

This thesis tests the concept of sector-specific regional capabilities and its analytical framework in an attempt to explain regional economic disparities in developing countries through a bottom-up analysis of the micro-foundation processes that change capabilities due to the interactions of the actors in systems. It complements and extends analyses that focus on understanding the implementation of top-down policies. Furthermore, it provides a clear framework within which to design future policies for sustainability in the short term vs. the long term in regional systems of innovation.

Supplementary Tables

Chapter 2

Table S2.1 Quotas and tariffs for powdered milk under NAFTA and WTO

Year	NAFTA quota imports (ton)	NAFTA over-quota tariff *ad valorem*, %	WTO quota imports (ton)	WTO over-quota tariff *ad valorem*, %	Maximum volume of imports free of tariff (ton)
1994	40,000	133.44	80,000	128	120,000
1995	41,200	127.88	80,000	128	121,200
1996	42,436	122.32	80,000	128	122,436
1997	43,709	116.76	80,000	128	123,709
1998	45,020	111.20	80,000	128	125,020
1999	46,371	105.64	80,000	128	126,371
2000	47,762	93.91	80,000	128	127,762
2001	49,195	82.18	80,000	128	129,195
2002	50,671	70.45	80,000	128	130,671
2003	52,191	58.71	80,000	128	132,191
2004	53,757	46.98	80,000	128	133,757
2005	55,369	35.25	80,000	128	135,369
2006	57,030	23.52	80,000	128	137,030
2007	58,741	11.79	80,000	128	138,741
2008	60,504	0.06	80,000	128	140,504

Source: SAGARPA (2000).

Table S2.2 Mexican pasteurisation industry, 1996

State	Installed capacity	Production	Used Capacity
	'000 litres/year	'000 litres/year	%
Aguascalientes	313,170	52,930	17
Baja California	209,875	142,350	68
Baja California Sur	12,775	9,855	77
Chihuahua	448,950	95,630	21
Coahuila	368,285	115,340	31
Durango	237,250	58,400	25
Colima	9,600	3,900	41
Distrito Federal	255,500	109,500	43
Estado de México	537,645	474,500	88
Guanajuato	69,350	73,000	105
Guerrero	36,500	25,550	70
Hidalgo	182,500	124,100	68
Jalisco	301,490	178,850	59
Michoacán	69,350	32,850	47
Nayarit	87,600	8,760	10
Nuevo León	277,400	46,355	17
San Luis Potosí	266,000	114,000	43
Sinaloa	87,600	42,340	48
Sonora	137,970	47,815	35
Tabasco	73,000	36,500	50
Tamaulipas	154,760	151,840	98
Tlaxcala	2,160	788	36
Veracruz	105,850	26,280	25
Total	4,244,580	1,971,433	46

Source: del Valle Rivera and Alvarez Macías (1997).

Table S2.3 (Some) world milk production features 1999-2003

	1999	2000	2001	2002	2003	CAGR, % (1999-2003)
Milk production ('000 tonnes)						
EU 15+10	144,383	143,004	143,657	143,839	144,032	0.1
US	73,807	76,004	75,068	77,139	77,252	0.1
Mexico	9,144	9,591	9,756	9,886	10,166	2.8
World	483,400	490,600	495,800	505,700	512,700	1.4
Productivity per cow (kg per year)						
EU 15	5,868	5,926	6,082	6,202	6,250	2.6
US	8,061	8,256	8,235	8,440	8,504	2.2
Mexico	1,325	1,368	1,397	1,410	1,450	3.0
Size of the dairy herd ('000 head)						
EU 15+10	-	25,536	24,949	24,450	23,952	-2.0 (2000-2003)
US	-	9,206	9,114	9,139	9,084	-0.6
Mexico*	-	2,075	2,140	2,183	2,170	1.5
Average producer milk prices (dollars/100 kg)						
EU 15	-	-	-	-	32.35	
US	-	27.33	33.15	26.85	27.67	
Mexico	-	24.70	25.24	25.81	25.00	
Production of liquid milk in dairies ('000) tonnes						
EU 15+10	33102	32,944	33,497	33,519	33,580	0.2
US	25,170	24,979	24,533	24,650	24,922	1.1
Mexico	3,733	3,765	3,632	3,881	4,000	3.1
Production of yogurt and fermented products (000) tonnes						
EU 15	6,400	6,500	6,600	6,790	6,900	1.6
US	792	833	909	1048	1083	3.3
Mexico	308	370	380	412	466	13.3
Production of cheese ('000) tonnes						
EU 15+8	6,951	7,157	7,409	7,472	7,534	0.7
US	3,581	3,746	3,747	3,877	3,900	0.6
Mexico	126	134	140	138	126	-8.6
Production of cream ('000) tonnes						
EU 15	1,690	1,713	1,804	1,758	1,757	-0.1
US	-	-	-	-	-	-
Mexico	76	88	101	114	117	2.6
Production of butter ('000) tonnes						
EU 15+8	1,854	1,835	1,824	1,880	1,890	0.5
US	597	570	559	615	564	-8.3
Mexico	15	16	15	14	16	11.3
Production of whole and semi-skimmed milk powder (000) tonnes						
EU	895	879	834	810	793	-2.2
US	54	51	19	22	18	-18.6
Mexico	109	118	110	114	116	1.5

Source: Author's estimations based on data from Richarts, Wohlfarth et al. (2004) and, for Mexican data, from SAGARPA (2005).

Chapter 4

Table S4.1 Interview guideline for firms' executives

Firm name:____
Date:____

Interviewee name	
Position in the organisation	
Years in the organisation	
Address	
Phone number	
Fax number	
E-mail address	
Time working with the agricultural sector	

1. Main features of the firm

a) Structure	Corporation?	
b) Year of starting business		
c) Locations	National	International
d) Ownership	□ 100% domestic capital	□ Joint venture with foreign capital - ------------%
e) Total farmers	Associated farmers No.	Other farmers No.
f) Average size of their herds		
g) No. of cows in production		
f) Average productivity per cow, litres/cow		

g) Total employees	2004/5	1999	1994
h) Total sales, Pesos/Dollars			
i) Total production of pasteurised milk/litres (Used capacity)			
j) Total pasteurisation capacity/litres per day/month/year			
k) Destination of the sales/production %			
National (States/cities in Mexico)			
Export (Countries) % Exports			
% R&D expenses/sales			
% Marketing expenses/sales			

2. Have you upgraded, modified or developed new technologies in the last 10 years? When? What did you do?

	Yes	When?	What have you done?
New products			
New product specifications			
New processes			
Focusing on new equipment			
Collection and distribution systems (Logistics)			
Conservation systems (Cooling systems)			
Added pasteurisation capacity			
Added other processing capacity (beyond pasteurisation)			
Packaging systems			
Raw materials			
Others			

Focusing on organisational change			
New routines or procedures (e.g. quality control or hygiene standards)			
Information systems and software			
Communication systems			
Others			

3. Have you received technological assistance in the last 10 years to make the technological changes? Who supported you in making the changes?

	☐ Yes ☐ No	Who?
To develop new products	☐ Yes ☐ No	
To develop new product specifications	☐ Yes ☐ No	
To develop new processes	☐ Yes ☐ No	
To purchase machinery and equipment (Production capacity)	☐ Yes ☐ No	
To develop new operations (quality control systems)	☐ Yes ☐ No	
To develop new collection and distribution systems (Logistics)	☐ Yes ☐ No	
To develop new conservation systems (Chilling systems)	☐ Yes ☐ No	
To develop new packaging systems	☐ Yes ☐ No	
To develop new materials and procurement of components	☐ Yes ☐ No	
To develop or to buy information systems and software	☐ Yes ☐ No	
Other (please specify)		

4. Are your technologies ahead or behind the industry in this region/nationally/internationally? How many years are you ahead or behind?

	Ahead/Yrs	Behind/Yrs	Average	I do not know
New products				
New product specifications				
New processes				
Machinery and equipment (Production capacity)				
New operations (To develop a quality control system)				
Information systems and software				
Collection and distribution systems (Logistics)				
Conservation systems (Cooling systems)				
Packaging systems				
Raw materials				
Others				

5. Does the firm have the following technical departments or functions? How many individuals are allocated to those functions?

	yes	no	Professionals	Technicians
R&D				
Engineering and design				
Prototype and development				
Cost production and pricing				
Testing market				
Others				

6. What have been the main sources of technology/knowledge in the last 10 years? What kind of relationship have you developed with them?

Source		Relationship/mechanisms
The firm relies on its own R&D, operation and design departments	☐ Yes ☐ No ☐ NR	
Suppliers of machinery and equipment – names?	☐ Yes	

	☐ No ☐ NR	
Public research centres – which ones?	☐ Yes ☐ No ☐ NR	
Universities – which?	☐ Yes ☐ No ☐ NR	
External recruitment of highly-qualified personnel	☐ Yes ☐ No ☐ NR	
Licensing – from whom?	☐ Yes ☐ No ☐ NR	
Clients – names?	☐ Yes ☐ No ☐ NR	
Competitors – names?	☐ Yes ☐ No ☐ NR	
Consultancies – names?	☐ Yes ☐ No ☐ NR	
Fairs, exhibitions, Where? When?	☐ Yes ☐ No ☐ NR	
Customers	☐ Yes ☐ No ☐ NR	
Chambers of commerce and industry associations	☐ Yes ☐ No ☐ NR	

7. If you have formal or informal linkages with local universities, public research centres, other foreign research institutions, what is the nature of the relationship? Have you benefited from the relationship?

☐ Universities ☐ Public research institutions ☐ Foreign research institutions	Which ones?	Achievements?
☐ Training ☐ Yes ☐ No		
☐ Stage for students ☐ Yes ☐ No		
☐ Exchange programmes with professors and engineers ☐ Yes ☐ No		
☐ Collaborative research projects ☐ Yes ☐ No		
☐ Other (please specify) ☐ Yes ☐ No		

8. Have you been involved in public support schemes to foster innovation? Which ones? When? Who else was involved?

		Which ones?	When?	Who?
Training	☐ Yes ☐ No			
Tax incentives	☐ Yes ☐ No			
Funds to develop new products or processes	☐ Yes ☐ No			
IPR support	☐ Yes ☐ No			
Exchange rate policy (for upgrading M&E or export incentives)	☐ Yes ☐ No			
Other (please specify)	☐ Yes ☐ No			

9. What are the firm's mechanisms for carrying out new technology projects?

Project management implementation process, software.	☐ Yes	☐ No
Own design control project with Excel and other tools	☐ Yes	☐ No
Experience but no documentation at all	☐ Yes	☐ No
Experience and systematic documentation of the implementation process	☐ Yes	☐ No
Contracts with third parties	☐ Yes	☐ No
Post-project assessment and systematic documentation	☐ Yes	☐ No
Others	☐ Yes	☐ No

10. Does the firm have any of the following operation and control systems? When did the firm start working with these systems? Who supported their development?

Operation and control system		When?
Quality control systems	☐ Yes ☐ No	
Just-in-time	☐ Yes ☐ No	
Continuous improvement	☐ Yes ☐ No	
Quality circles, teamwork	☐ Yes ☐ No	
Internal production manuals	☐ Yes ☐ No	
Internal operation manuals	☐ Yes ☐ No	
Six Sigma	☐ Yes ☐ No	
HACCP	☐ Yes ☐ No	
ISO 9000	☐ Yes ☐ No	
Best practices (EPA)	☐ Yes ☐ No	
Other		

11. Has the firm provided employee training in the last 3 years?	☐ Yes	☐ No
If yes, is it in-house training or externally provided?	☐ In-house training	☐ Externally provided Who?
What kind of training?		
Technical/technological		
Managerial/operations		
Accountancy and Finance		
English/foreign language		
Information technologies		
Other		

12. What do you consider are the main technological strengths (capabilities) of the firm, which can be exploited in the future? Why do you think so?

	Yes	Why?
To develop R&D activities (products, process, operation, marketing, engineering, etc.)		
To use or develop patents		
To develop and support industrial secrets		
To develop new operations (i.e. integration of suppliers, integration of distribution systems, etc.)		
To assess business opportunities		
To buy firms, 'take-over process'		
To develop franchises		
To develop joint research with other organisations (technology, marketing, etc.)		
To develop alliances (business, technology, market, etc.)		
To carry out in-house equipment and machinery maintenance activities or to outsource them		
Others (please specify)		

13. What do you consider are the main organisational capabilities of the firm that can be exploited in the future, and why?

	Yes	Why?
To develop the teams to plan and implement new projects inside the firm		
To outsource different suppliers of technology/operations		
To develop inter-organisational teams with other organisations (suppliers, clients, government agencies, etc.) to develop new projects		
To systematically formulate business/technology strategies a) Short term b) Long term		
To formulate business/technology strategies when the threats appear		
To get finance support for innovation processes		
To systematically interact with other agents in the system to develop new projects/business		

14. What are the mechanisms developed with your suppliers that you consider have been the most important for your success and why?

	Why
Payment scheme for raw fresh milk	
Purchasing contracts of raw fresh milk (verbal and formal)	
Supply/demand contracts with farmers	
Supply/demand contracts with retailers	
Finance support from banks and other finance organisations	
Technical/technological support from third parties	
Managerial support (changing the business)	
Packaging materials technology transfer	
Services supplier (i.e. maintenance services)	
Others	

15. What have been the main relationships with suppliers and in the region that have influenced your performance? Who?

Relationship		Who?
Integration with farmers		
Supporting farmers		
Outsourcing technology from suppliers, universities and research institutes		
Lobbying government agencies: importing skimmed milk powder, dairy products, milk distribution for social programmes, etc.		
Forming alliances with other parties Who are they?		
Other (please specify)		
The firm has achieved success by itself		

16. From your point of view, how important are the following barriers to innovate in the firm? Why?

External factors		**Why?**
Excessive perceived economic risk		
Innovation costs too high		
Insufficient flexibility of regulations and standards		
Lack of customer responsiveness to new products		
Lack of economic support (banks, risk investment, etc.)		
Lack of institutional support (government, research institutions, universities, etc.)		
Other (please specify)		
Internal factors		
Organisation rigidities within the enterprise		
Lack of qualified personnel		
Lack of information on technology		
Lack of information on markets		

Lack of technological capabilities in the firm		
Lack of organisational capabilities in the firm		
Lack of interest		
Other (please specify)		

17. What are the main strengths (competitive advantages) and weaknesses of the firm? Why do you think so?

Strengths/Why	Weaknesses/ Why
1.	1.
2.	2.
3.	3.

18. What are the 3 main firm capabilities to improve **competitiveness** in the near future?

19. Do you think NAFTA has speeded up the firm for change, for growth, etc.? Why?

20. Has the dairy sector become more important in the region after NAFTA? Yes or no. Why do you think so?

21. What have been the main contributions of the firm to the development of the **regional** dairy system? Why?

22. What have been the main contributions of the firm to the development of the **national** dairy system? Why?

23. Who would be the main actors in the development of policies in the region and in the system?

THANKS!!!

Table S4.2 Interview guideline for supporting organisations' executives

1. General information

Interviewee's name	
Position in the organisation	
Years in the organisation	
Address	
Phone number	
Fax number	
E-mail address	
Time working with the agricultural sector	
Starting date of the organisation in the region	

General information of the organisation			
No. of employees	Years of schooling	Ages	
Researchers			
Administrative			
Knowledge outcome:			
Number of publications 2000-2004			
Formal research contracts with other organisations 2000-2004			

2. Who do you consider are the main actors in the development of the dairy region? Why?

Regional dairy system actors	Why?
Farmers	
Firms	
INIFAP	
Universities	
FIRA	
SAGARPA regional office	
Machinery and equipment suppliers	
Animal health service suppliers	
Feedstock suppliers	
Banks	
Consultants	
Others (please specify)	

3. What are the 3 main achievements of the farmers/dairy firms in the development of the dairy sector in the region? (Technological and organisational?)

Achievements	Technological and organisational?

4. What were the main activities/mechanisms behind those achievements? Who else was involved in the activities/mechanisms?

Organisation	Activities/mechanisms Examples: training programmes, financial support, etc.

5. What has been the role of the universities, educational institutions and other support organisations in the development of the dairy sector?

Name of the organisations	Roles
Universities:	
Research institutes:	
Profesional associations:	
Other (please specify)	

6. What should be the main activities/mechanisms of the institution for the future development of the dairy sector in the region? Who should be involved in those activities/mechanisms?

Organisation	Activities/mechanisms Examples: Internal resources, external resources, integration of the value chain, changes in the national policies, changes in the foreign trade policies, etc.

7. What have been the main constraints on the institution to supporting dairy farmers and other actors in the dairy system in the region?

Actors	Constraints

8. How has NAFTA influenced the changes in the dairy sector in the region?

Threats	Opportunities

Comments:
____
____

9. What are the main constraints on the actors of the regional dairy system to increasing the competitiveness of the system?

Regional dairy system actors	Constraints
Farmers	
Firms	
INIFAP	
Universities	
FIRA	
SAGARPA regional office	
Machinery and equipment suppliers	
Animal health service suppliers	
Feedstock suppliers	
Banks	
Consultants	
Others (please specify)	

10. Do you think that the region has individuals with the necessary knowledge and skills to support further development of the dairy sector? Examples: Education, resources, etc.
____
____
____

11. Has the dairy sector become more important in the region after NAFTA? Yes or no. Why do you think so?
____
____
____

THANKS!!!

Chapter 5

Table S5.1 Grupo Industrial Lala structure

Firms	Business
Grupo Industrial Lala	Corporation services
Lala Arrendadora de Monterrey	Corporation services
Lala Arrendadora de Mexico	Corporation services
Lala Administracion y Control	Corporation services
Servicios Corporativos de la Laguna	Corporation services
Unión de Crédito Industrial y Agrícola La Laguna (UCIALSA)	Financial services
Lala Torreón, S.A. de C.V.	Dairy facility
Lala Derivados Lacteos, S.A. de C.V.	Dairy facility
Productora de Lácteos de Torreón	Dairy facility
Lala Durango, S.A. de C.V.	Dairy facility
Lala Monterrey, S.A. de C.V.	Dairy facility
Lala México, S.A. de C.V. (2)	Dairy facility
Lala Guadalajara, S.A. de C.V. (2)	Dairy facility
Lala Acapulco, S.A. de C.V.	Dairy facility
Lala Mazatlán, S.A. de C.V.	Dairy facility
Prolac del Sureste (2)	Dairy facility
Ultralala, S.A. de C.V.	Dairy facility
Industrias Lácteas de La Laguna	Dairy facility
Campofrío México	Dairy facility
Tecnopack de La Laguna	Packaging material facility
Lala Elopak	Packaging material facility
Distribuidora de Envases Elopak	Packaging material distributor
Enfriadora de Productos del Campo	Transport and logistics services
Productos y Servicios Integrados de México	Transport and logistics services
Servicios Especializados de Transporte y Logística	Transport and logistics services
Trax Llantas	Supplier of inputs for transport
Transportadora de Alimentos	Feedstock and other inputs for milk production
Abastecedora de Alimentos de México	Commercialisation of products
Fundación Grupo Lala	Social organisation to supply milk to orphans

Sources: Author's elaboration of data from Lala website:
http://www.lala.com.mx/nuestra_empresa/frame_master_nuestra.html (March 25, 2006).

Table S5.2 Training programmes of the ITESM Campus La Laguna

Recipient and period of training	**Training programmes**
SAGARPA, 2005	Certificate of management in agribusiness: 1. Diploma in managerial skills: Coaching for managers, Mental maps, Self-esteem, and emotional intelligence, Development of intelligent organisations, Neuro linguistics programming, Problem analysis. 2. Diploma in agribusiness management: Market development, Operations management, Agribusiness strategies, Food trade, International trade. 3. Diploma in management: Quality and productivity, Project management, Specialised topics in agribusiness, I, II and III
INIFAP, 2004-2005	Managerial skills development: Negotiation process, Responsiveness to change, Self-esteem and emotional intelligence, Process improvement, Project management
Lala, 2005	Managerial skills development: Responsiveness to change, Neuro linguistics programming, Emotional intelligence, Effective communication, Conflict management, Service attitude, Working in teams, Problem detection and decision making, Business vision and value chain, Organisation planning and control, Leadership and empowerment
Leche Bell, 2005	Managerial skills development: 1. Developing competences for world class management: Leadership with high yield performance, Managerial skills, Emotional intelligence, Effective time management, Health and work, Operation management, Effective communication, Self directed teams, Quality culture development, Looking for excellence 2. Strategic planning to develop leaders 3. Assessment of competences of the leaders
Local Farmers, 2000-2005	Continuous improvement programme: Responsiveness to change, Working in teams
Financiera Rural, 2005	Managerial skills development: Responsiveness to change, Self-esteem, emotional intelligence, Neuro-linguistics programming

Source: Author's elaboration of information from ITESM Campus La Laguna, Centro de Competititvidad Internacional (Becerra Huerta 2005; Facio Lícera 2005).

Table S5.3 (Some) publications of the La Laguna dairy region

Publication/dates	Responsible/Authors
Annual publication: "El Impacto Social y Económico de la Ganadería Lechera en la Región de La Laguna" (The Social and Economic Impact of the Dairy Livestock in the La Laguna region) (1993-2000)	President of the UGR La Laguna, President of the Lala Board and ENGALEC
Periodical/magazine: Unión Ganadera magazine (1995-)	The official magazine of the UGR La Laguna
Magazine: "Revista Mexicana de Agronegocios" (Mexican Agro Business Magazine) (1997-)	"Sociedad Mexicana de Administración Agropecuaria" (Mexican Association of Agro Business)
Book: *Diagnóstico situacional estratégico en empresas lechera: El caso de la Comarca Lagunera (Diagnostic of milk and dairy firms: The case of La Comarca Lagunera)* (2004)	Multidisciplinary and inter organisational research (i.e. "Sociedad Mexicana de Administración Agropecuaria", (UAAAN and the Universidad Autónoma de La Laguna, A.C.)
Agribusiness books: 1) Marketing guide for agribusiness management, 2) Glossary for agribusiness managers and economists, 3) Handbook of administration of agribusiness, 4) Economy of agribusiness, 5) Strategic planning in agribusiness), 6) Ethics in agribusiness.	Dr. Agustín Cabral Martel, Dr. Alfredo Aguilar and Eng. Guillermo Guerra (Researchers and consultants in agribusiness in La Laguna region)
Book: *La globalización productiva y comercial de la leche y sus derivados* (*The globalisation of milk production and dairy products)* (2005).	García Hernández, L. A. Aguilar Valdes, A. et al., (2005)
Book: *La globalización del sistema lechero en La Laguna: Estructura productiva, desarrollo tecnológico y actores sociales (The globalisation of the dairy system in La Laguna: Production structure, technological development and social actors).*	Martinez Borrego, E. and Salas Quintanal, H. (2003)
Book: *Antropología, estudios rurales y cambio social. La globalización en la region Lagunera (Anthropology, rural studies and social change. Globalisation in La Laguna region).*	Salas Quintanal (2002)
Book: *Globalización e integración regional en la producción y desarrollo tecnológico de la lechería mexicana (Globalisation and regional integration in the production and technological development of the Mexican dairy)*	Martínez Borrego, E. and H. Salas Quintanal (2002)
Book chapter: "La ganadería lechera en la Comarca Lagunera. Uso de recursos naturales y tecnificación" (The dairy livestock in La Comarca Lagunera region) in *Apertura y desencadenamientos productivos-reflexiones en torno a los lácteos*	Martinez Borrego, García Hernández, L. A. and Salas Quintanal, H. (2000)
Book chapter: "La experiencia del cooperativismo en el subsector lácteo. El caso de la Laguna", (The experience of cooperativism in the dairy subsector. The case of La Laguna) in *Los pequeños productores rurales: las reformas y las opciones*.	Martínez Borrego, García Hernández, L. A. and Salas Quintanal, H. (Coordinators) (2000)
Development of a "hemeroteca" for dairy development since 2000	Lomelí Monreal (2005)

Table S5.4 PROLEA: A successful dairy farmers organisation in Los Altos

PROLEA (*Productores de Leche de Acatic, Sociedad Cooperativa Limitada)* is a dairy farmers' organisation in Acatic, a municipality in the Los Altos region. PROLEA started as a rural association of dairy farmers and 'ruteros' (i.e. Sociedad de Producción Rural, SPR) in the early 1980s to access BANRURAL resources for the purchase of agricultural machinery. The absence of a common goal among members resulted in only 44 members in 1991. PROLEA obtained resources from Lechera Guadalajara and FIRA to import 900 Holsteins to start milk production. PROLEA owns 3% of the shares of Alimentos La Concordia. By 2005, PROLEA was supplying an average of 53,000 litres per day to Alimentos La Concordia and had 150 members and 2,000 cows in production. Five members had more than 100 cows, the remaining 145 had less than 20 cows in production. Average productivity per cow was 20 litres per day per cow, which was high for the region. Some farmers were still milking manually. The region has strong agriculture and livestock production and many dairy farmers diversified into hog and poultry production because small scale milk production was not profitable (an average of 50 cows is considered a break-even number). PROLEA is an entrepreneurial organisation, which has succeeded in several complementary milk production projects such as a) commercialisation of maize for forage, which started in 1994 to reduce costs of transporting from production areas in Aranda and Tepatitlán to Acatic. PROLEA accessed resources from the Jalisco State, the federal government, dairy farmers, Lechera Guadalajara, and collaborated with the region's maize farmers to set up silos to ensure continuous supplies of maize. Based on PROLEA's success, other milk cooperatives (i.e. Unión de Cooperativas Alteñas) implemented similar projects; and b) establishing a centre for raising Holstein heifers for replacement animals, which started in 1995 to preserve herd genetics. PROLEA has no R&D department; however, it has an ambitious technological portfolio of projects with INIFAP Jalisco, suppliers of seeds and the Universidad de Guadalajara, which includes: a) development of intensive grazing systems; b) transplanting embryos; and c) production of sexed semen. PROLEA is also involved in social projects to help the families of its members, e.g. medical services, sponsorship for graduate and undergraduate students, dairy bulletins, psychological assistance for children and young people, veterinary and management training and teaching of English as a second language. PROLEA has developed project management capabilities with the participation of some of its members. However, it does not have the strategic capabilities required to align members' objectives to a common vision, which would speed up decision making. It also lacks the capabilities to produce dairy products. The success of the PROLEA organisational model has attracted students from the University of Wisconsin to study this model, which has also successfully attracted economic resources from Alianza para el Campo and FIRA.

Source: Based on an interview with Ramírez González (2005a).

Table S5.5 Los Altos region, milk quality improvement based on reductase test

Year	Minimum without price reduction (minutes of reductase test)	Minimum to get premium price (minutes of reductase test)
1994	330	ND
1995	370	ND
1996	400	ND
1997	400	450
1998	400	450
1999	400	450
2000	400	450
2005*	400	650

* Data from Hernández León (2005).

Source: Cervantes Escoto, Santoyo Cortés, et al. (2001).

Table S5.6 Technological level of family milk production systems in Los Altos region

Components from intensive model	Technological level					
Artificial insemination	Extensive use				Not used	
Alfalfa supply	Yes		No		No	
Milking system	Mechanical		Mechanical	Manual	Mechanical	Manual
Organisation to commercialise chilled milk	Individual chilling tank	Collective chilling tank	Collective chilling tank		Collective chilling tank	
Technological level*	Modern technology, 5%	Modern technology, 8%	Medium technology, 19%	Medium technology, 6%	Traditional technology, 14%	Traditional technology, 34%
Specific features of the systems						
Grazing	No		Yes			
Cows in production	30-45	35-40	22-25	10	23-27	14
Average age of the milk producer	40	55	58	51	58	44
Farmers' experience, years	20-23	33-35	28	25-33	30	15-18
Hectares for agriculture production	21-23	10-12	11-13	4-5	13-25	9-11
Labour for animal	0.12	0.11	0.12	0.26	0.14	0.25
Organisation for feedstock production	Yes	No	No	Yes	No	No
Productivity per cow, litres/day	23	18	16	17	15	14
Profit per litre, Pesos	0.47	0.24	0.19	(0.04)	0.16	(0.36)
Profitability	High	High	Media	Negative	Media	Negative

* They add 86%; the other 14% of the sample were not classified because they do not match the proposed methodological classification used by the author.

Source: Author's elaboration of data from Cervantes Escoto, Santoyo Cortés, et al. (2001), pp 153-154.

Table S5.7 Los Altos region commercialisation of raw fresh milk, 1998-2005

Milk and dairy processors	Participation in the collection of milk (1998)	Participation in the collection of milk (2005)*
Large: Lechera Guadalajara, Nestlé, Sigma Alimentos, Alimentos La Concordia, Lala and Alpura	74%	87 %
Medium: LICONSA, Acción Ganadera, PROLAJSA and ALPRODEL	9%	LICONSA, 7%**
Small: Cecoopal, Lácteos del Fuerte, Lácteos Gama, Lácteos Gosa, 19 Hermanos, etc.	4%	Small milk processors and fresh milk consumption, 6%
Non-pasteurised milk	13%	

* Estimations based on data from Falcón Estrada (2005).
** No data available for the other firms.
Source: Author's elaboration of data from Cervantes Escoto, Santoyo Cortés, et al. (2001) p. 95-96.

Table S5.8 Lechera Guadalajara subsidiaries

Subsidiaries	Economic activity
Alimentos La Concordia	Industrialisation of milk and commercialisation of dairy products
Plásticos Las Palmas	Plastic injection for the production of packages
Impresos Uyeda	Design and printing of labels for flexography systems and bordering
TEISA	Design and construction of industrial tanks
CEIBA	Construction services for industrial facilities
DANIU	National and international distribution of foodstuffs
SAHOLD	Bulk transportation of foodstuffs
REMPLASA	Recycling of polyethylene and production of industrial containers
Transliquid Guadalajara S.A.	Cooling transportation systems

Source: Author's elaboration with data from Lechera Guadalajara website: http://rojo.sellorojo.com.mx/ (July 25, 2006).

Table S5.9 Sigma Alimentos evolution of networks of suppliers of chilled milk

Supplier of chilled milk	1999	2001	2005
Total:			
Sociedad de Producción Rural	49	44	20
Individuals	24	74	243
Size of the herd:			
Sociedad de Producción Rural	NA	15	21
Individuals	NA	70	71
Cows in production:			
Sociedad de Producción Rural	NA	11	15
Individuals	NA	50	51
Average productivity litres per cow:			
Sociedad de Producción Rural	16	13	15-17
Individuals	16	22	25-30

Source: Author's elaboration of data from Quintanilla Alvarez (2006).

Table S5.10 COFOCALEC milk and dairy norms

Norm denomination	Description	Publication date
NMX-F-700-COFOCALEC-2004	Raw fresh milk. Sistema Producto Leche – Alimento – Lácteo – Leche cruda de vaca – Especificaciones fisicoquímicas, sanitarias y métodos de prueba.	23/06/ 2004
NMX-F-701-COFOCALEC-2004	Ashes in cheese. Sistema Producto Leche – Alimentos – Lácteos – Determinación de cenizas en quesos – Método de prueba	23/06/ 2004
NMX-F-702-COFOCALEC-2004	Phosphatase test in dairy products. Sistema Producto Leche – Alimentos – Lácteos – Determinación de fosfatasa residual en leche, fórmula láctea, producto lácteo combinado, helados y sorbetes – Método de prueba.	23/06/ 2004
NMX-F-703-COFOCALEC-2004	Fermentation materials. Sistema Producto Leche - Alimentos – Lácteos – Leche y producto lácteo (o alimento lácteo) – Fermentado o acidificado – Denominaciones, especificaciones y métodos de prueba.	30/11/2004
NMX-F-704-COFOCALEC-2004	Mechanical milking equipment. Sistema Producto Leche - Equipo para ordeño mecánico – Especificaciones y métodos de prueba.	30/11/2004
NMX-F-705-COFOCALEC-2004	Total bacterial count. Sistema Producto Leche - Alimentos – Lácteos – Determinación de la cuenta total bacteriana, en leche cruda, por citometría de flujo – Método de prueba.	30/11/2004
NMX-F-706-COFOCALEC-2004	Total somatic cell count. Sistema Producto Leche - Alimentos – Lácteos – Determinación de la cuenta de células somáticas, en leche cruda, por citometría de flujo – Método de prueba.	30/11/2004
NMX-F-707-COFOCALEC-2004	Phytosterols in dairy products and formulas. Sistema Producto Leche - Alimentos – Lácteos – Determinación de fitosteroles en leche, fórmula láctea, producto lácteo combinado, queso, crema y mantequilla, por cromatografía de gases – Método de prueba.	30/11/2004

Source: Author's elaboration of data from COFOCALEC web site: http://cofocalec.org.mx/espanol/Normalizacion.htm (February 25, 2006).

Table S5.11 Tabasco milk production and Ultralácteos catchments of milk, 1994-2004

Year	Tabasco production litres*	Ultralácteos catchments litres**	Ultralácteos catchments of milk, %
1994	90,114,000	34,000,000	38
1995	87,954,000	31,000,000	35
1996	83,730,000	27,000,000	32
1997	85,800,000	35,000,000	41
1998	83,978,000	29,675,180	35
1999	83,475,000	34,286,605	41
2000	85,754,000	38,148,696	44
2001	89,311,000	47,847,951	54
2002	88,610,000	55,127,599	62
2003	96,041,000	59,416,501	62
2004	99,432,000	64,104,006	64

Source: * SAGARPA 2005 and ** estimated from Muñoz Rodríguez, García Muñiz, et al. (2003) and Morales Gómez (2005).

Table S5.12 UGR Tabasco structure

Organisation (year of foundation)	Main activities
Ultralácteos S.A. de C.V. (1989)	Pasteurising facility and dairy processor
Frigorífico y Empacadora de Tabasco, S. A. de C. V. (1962)	Slaughterhouse and meat packing facility
Unión de Crédito Ganadero de Tabasco S.A. de C.V. (UCGT) (1979)	Credit union to support the development of livestock in Tabasco
Cooperativa de Consumo ‘Ganadero’ SCL (1979)	Cooperative to supply inputs to dairy farmers in the region with 13 000 associated members. It has 39 shops: 23 in Tabasco, 5 in the South of Veracruz, 6 in the North of Chiapas and 5 in Campeche. It had sales of 20 million dollars in 2004.
Comité para el Fomento y Protección Pecuaria del Estado de Tabasco, S.C. (CFPPET) (1989)	Civil association, which has 5 pathology laboratories in Balancán, Tenosique, Huimanguilla and Villahermosa. It has a laboratory of bromathology in Villahermosa and semen banks in Balancán, Tenosique, Comalcalco and Villahermosa.
Alimentos Balanceados Unión, S.A. de C.V. (1994)	Feedstock production facility
Transportadora de Cárnicos y Derivados Unión, S.A. de C.V. (1999)	Transportation services of cattle and beef

Source: Author’s elaboration of information from UGR Tabasco website: http://www.ugrtab.com (September 25, 2005).

Table S5.13 Tabasco university programmes for education related to agriculture, livestock and food technology

AMMVEB	Master and specialisation programmes for veterinarians in bovine reproduction
CEBETIS	Technical programmes for agriculture and related areas
CONALEP	Technical programmes for agriculture and related areas
COLPOS Cárdenas	An agribusiness MSc programme in tropical regions, which includes agriculture, animal production, environment and sustainability and milk commercialisation; and a PhD programme focused on animal production and dual-purpose systems.
ITA No. 28	Technical programmes for agriculture and related areas
ITV	Specialisation programme in food industry
UJAT	Undergraduate programme in veterinary and food science and MSc programmes in veterinary science, animal production and food science
UTT	MSc programme in food processing
UPCh	Undergraduate programme for veterinary science and agriculture and areas of research to meet specific regional demands

Sources: Author's elaboration with information from Aranda Ibañez (2005), Guiot García (2005).

Table S5.14 Tabasco livestock training programme assessment 2003 and 2004

	2003		**2004**	
Technological courses	Days	Attendants	Days	Attendants
Systems for bovine reproduction	7	8	5	23
Artificial insemination	6	55	12	39
Quality control for milk production units (Good manufacture practices, GMP, in milk production)	3	179	30	161
Herd management using software	6	41		
Production of dairy products	5	123	30	161
Management of electric fences	2	76	6	78
Management of bovine systems	5	29	2	22
Introduction of technology in intensive grazing systems	3 (I level) 3 (II level)	224 (I level) 182 (II level)	9 (I level) 6 (II level) 3 (III level)	63 (I level) 44 (II level) 24 (III level)
Silage production			3	30
Management courses				
Management of agricultural enterprises	2	130		
Organisational behaviour and change management	3	20		
Development of management capabilities	6	32		
Leadership in agricultural firms	2	32		
Planning and sales of technical assistance	5	23		
Effective presentations to affect the decision-taking process	3	34		
Marketing strategic planning	3	20		
Index of Valuation of the Program (IVP) >1 High valuation, <1 poor valuation	0.70*		0.78*	
Scope	4%		3%	
Focused population	1.12		1.09	
Efficiency	0.95		1.22	
Training Investment/Livestock GDP	0.078		0.074	

* Estimated on data from Programas de Capacitación del Gobierno del Estado de Tabasco (2003) and (2004). The low values indicate poor valuation due to the low scope of the training programme, 4% of the target population for 2003 and 3% of the population in 2004.
Sources: Author's elaboration with data from SEDAFOP (2003); SEDAFOP (2004).

CHAPTER 6

Table S6.1 State of bovine diseases in the dairy regions studied

Regions	Tuberculosis	Brucellosis	Rabies	Tick infestation
La Laguna	Control	Control	Natural free	Natural free
Los Altos	Control	Control	Control	Control
Tabasco	Control	Control	Control	Control

Control: First stage of eradication of the disease, but still frequent outbreaks.
Eradication. Rare outbreaks of the diseases and vaccines disallowed.
Free. More than 12 months with no outbreaks.
Natural free because of the absence of bats in the regions, the agents responsible for transmitting the disease.
Source: PRODEVIT website: http://project.jica.go.jp/mexico/2451084E0/spanish/info/01.html#table03 (September 25, 2006).

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Appendix I The political context of the Mexican Dairy Sector (MDS)

List of Tables

List of Figures

Introduction

The current ‘unitary’ national agriculture policy, which is a mix of neo liberal policies, targeted social programmes, and limited regionally oriented policies, appears to be falling short in terms of Mexico’s aspirations to achieve a sustainable and expanding domestically controlled dairy system.

To demonstrate the inadequacy of this unitary national policy we need to examine how it has worked in practice since NAFTA (1994-2004) which requires an understanding of the complex structure of actors and institutional arrangements, i.e. the political context of the MDS, which have affected the integration of dairy farmers and dairy processors in their regions. Dairy farmers and firms have coevolved with their underlying supporting actors, their networks and institutions gaining more coherence in some cases than in others, depending on their regional arrangements. A summary of the main impact of the changes in the political context of the MDS is provided in the Table 2.1 in Chapter 2.

This Appendix has four sections. Section 1 explains the government organisations and the agriculture policies and institutions, which constitute the complex structure, which, in different ways, has influenced the dairy regions over a long turbulent economic and political period. It explains how the agriculture development programmes evolved from mitigating the effects of the opening of the trade policy to attempting to improve productivity and competitiveness in milk production systems through linkages of users-producers of knowledge within the system (e.g. PROCAMPO, Alianza para el Campo and SNIA). This section also explains the complex role played by LICONSA to supply inexpensive milk for the low-income population and to regulate the market for NFDM. Section 2 explains the different roles played by the dairy MNCs supporting dairy development (the case of Nestlé), and the role of the MNCs’ suppliers of inputs for milk and dairy production to upgrade milk and dairy production technologies. Section 3 explains how livestock producers’ associations and professional associations have influenced the government to attract resources and to carry out some development activities for the integration of the value chain. Section 4 summarises the insights gained about the actors and institutions of the MDS, which have affected the dairy regions’ development.

1. MDS government structure, agriculture programmes and institutions

The Mexican agricultural sector has had a long and problematic history of poverty and segregation of the rural population since the Conquest [1] that led to the war of Independence that started in 1810 and ended in 1821, and the Mexican Revolution in 1910. [2] Since then, the Mexican government has had programmes to support the development of agriculture infrastructure for irrigation, electrification and communication. As a result, in 1940s and 1950s huge increases in grain production occurred the national market in the north, north west and centre of the country (Ekboir, Espinosa García et al. 2003). This was part of the Import Substituting Industrialisation (ISI) regime, which prevailed from 1930s to early 1980s (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000).

Until the mid 1980s, the agriculture sector had several policies including direct and indirect subsidies (e.g. price control for basic grains and subsidies for electricity and irrigation water), control over the commercialisation of agriculture commodities by CONASUPO,[3] control of imports of capital goods for agriculture and large investment in irrigation and agriculture research. These policies aimed to achieve self-sufficiency in food supply and to support small producers to remain economically active. Neither competitiveness nor economic sustainability were policy priorities (Ekboir, Espinosa García et al. 2003).

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[1] Livestock production, unlike agricultural production has been a high status activity since the Conquest. The expansion of livestock production created conflicts with the indigenous people, who were the labour employed on the 'haciendas' (i.e. large farms owned by Spaniards or 'hacendados' or 'latifundistas', owners of large pieces of land). With the evolution of society and growth of mestizo (descendents of Spanish and Mexican native parents) and 'criollos' (Spanish descendents born in Mexico) participation in this economic activity, there was a social transformation that presented problems which led to the Independence war in which 'hacendados' sought appropriation of the full rents of land exploitation without sharing with Spain Crown.

[2] The Mexican Independence War was characterised by an economic crises in La Nueva España (now Mexico), which included low economic growth including the agriculture sector and instability in the rural regions because of the exploitation of the indigenous people and the increase in the poverty of the urban population (Bassols Batalla 1992). During the Mexican Revolution, the indigenous people sought land ownership to appropriate rents. This led to the creation of large private farms alongside the 'ejidatarios' (communal land), and small private owners which were consolidated in 1936, when President Cárdenas promoted an agrarian structure. This reform spurred important agricultural growth that persisted until the 1970s (del Valle Rivera, Chávez Hoyos et al. 1996). This reform was amended in 1992, when the land tenure for 'ejidatarios' changed.

[3] CONASUPO was the oldest state trading firm, which administrated assistance programmes to poor families consisting subsidised beans, tortillas, and milk, among other products. It has a history of corruption and was used by the PRI (the Revolutionary Institutional Party, which ruled Mexico for over 80 years, until 2000) as a source of support for its power (Aragón Mladosich and Gómez Ibañez 2004) .

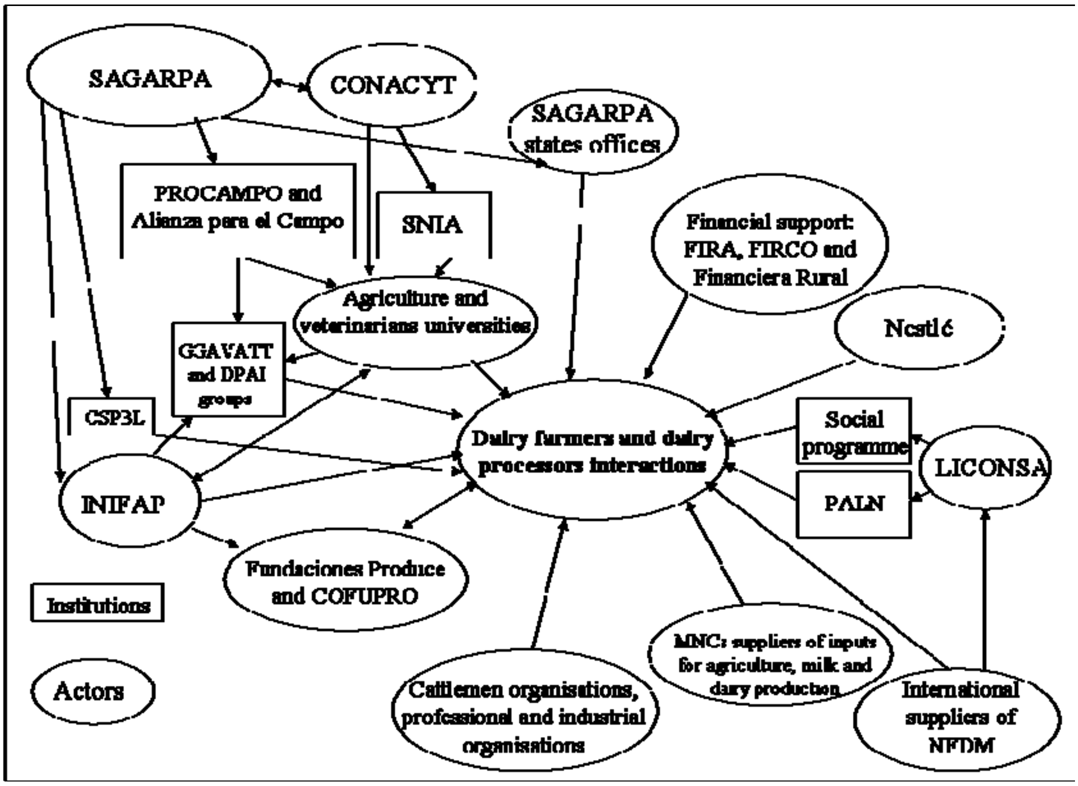
During the late 1980s, mainly large and private farmers integrated with agribusiness through the incorporation of foreign technologies. The result was an important technological innovation process through which productivity increased dramatically.[4] Private farmers (i.e. mainly non-'ejidatarios') responded to the demand for vegetables and fruit for foreign markets and milk, beef, hogs and poultry for the domestic market. These policies, however, were not enough to make the country self-sufficient in food production and many agriculture activities in the sector were low in productivity and competitiveness (Ekboir, Espinosa García et al. 2003). Milk production was also struggling in the modernisation processes and was strongly dependent on Federal agriculture policies, e.g. the 'Tanques Rancheros' programme (i.e. the creation of infrastructure of chilled tanks for milk collection in the temperate region in the late 1980s) (McDonald 1997; McDonald 1999; del Valle Rivera 2000; Cervantes Escoto, Alvarez Macías et al. 2001; McDonald 2001), and the high participation of FIRA to support the development of the specialised herd for milk production (del Valle Rivera 2000; Cervantes Escoto, Alvarez Macías et al. 2001). Since then, the MDS has experienced numerous problems, which have afflicted the sector for a long period, and became more severe after NAFTA (Rodríguez Gómez 1998a; del Valle Rivera 2000; Martínez Borrego and Salas Quintanal 2002) because of its technological disadvantages (Alvarez Macías 1999; del Valle Rivera 2000; Muñoz Rodríguez, García Muñiz et al. 2003).

Traditionally, the top-down centralised agriculture policy has had different effects on the regionalised structure of milk production systems (i.e. specialised, semi specialised and dual-purpose systems) and their integration with dairy firms. Since this integration has been a major force in the development of the MDS; the diversity of policy instruments (e.g. policies regarding production of grains and grazing for feedstock production, land tenure regime, etc.) and the multiple organisations that promote the institutions to implement agricultural policies have influenced the innovation process in the regional dairy systems (Alvarez Macías 2005; Cervantes Escoto 2005; del Valle

[4] Agriculture sector participation in the national economy has been declining and generated just 5% of GDP and 2.5% of exports in the 1990s. Nevertheless, it is still a very important economic and social sector because it generates approximately 25% of total employment and has a big influence in the rural areas, where 75% of the poorest population is concentrated, and 50% of whom live in extreme poverty. Furthermore, agriculture exports are very important for some regions, which have irrigation systems (e.g. north and central parts of the country) (Ekboir, Espinosa García et al. 2003).

Rivera 2005; Rodríguez Gómez 2005). However, the regional actors and their socio economic and cultural set ups have influenced how top-down policies were implemented to an extent.

Figure A1 (and Figure 2.1 in the main text) illustrates the main actors and institutions in the MDS, which have influenced the integration of the value chain (i.e. dairy farmers and dairy processors) and could influence the long-term sustainability of the MDS. Below we discuss their role in the integration of the value chain, and consequent development of capabilities in the MDS.



Source: Author's elaboration.

Figure A1 Mexican Dairy System of Innovation

1.1 SAGARPA and the Federal programmes affecting milk production: PROCAMPO and Alianza para el Campo

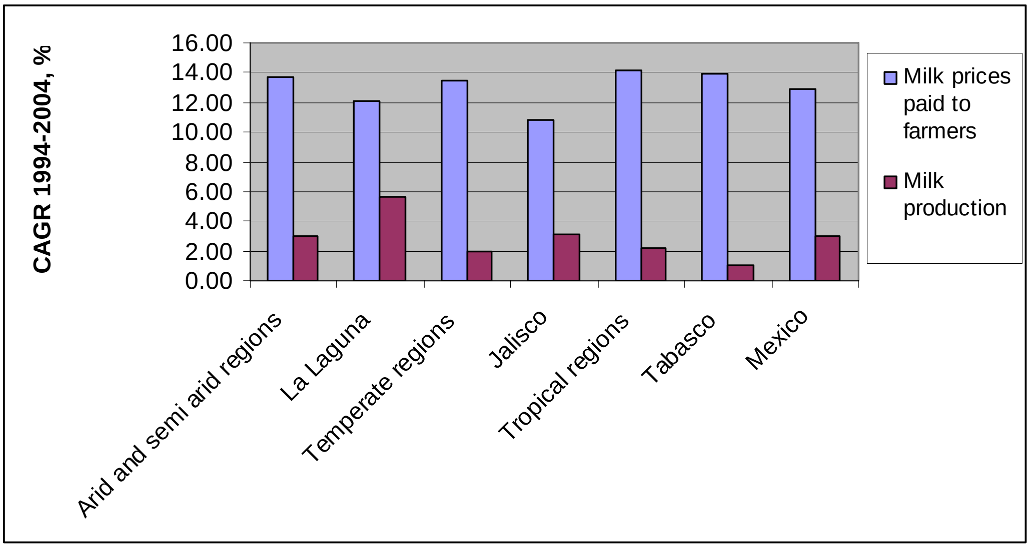
SAGARPA's agriculture policy is the latest effort in an almost century long process aimed at developing and strengthening the agriculture sector (Ekboir, Espinosa García et al. 2003). According to del Valle Rivera (2000), two main policies have affected the evolution of the MDS. First, those addressing the operation of the milk and dairy market, via milk price regulation, and second, those policies addressing the development of milk production with both intended and unintended consequences.

a) Milk prices regulation

In 1974, a policy to control the price of pasteurised milk was established to protect consumers and to increase milk consumption. The policy set a reference price for dairy processors to paid dairy farmers, which included subsidies for the cost of feedstock used for milk production. In 1989, this reference price was abolished and two new mechanisms[5] were created to fix regional prices, i.e. 'concerted prices' for raw fresh milk and pasteurised milk aimed at protecting consumers during the economic crises that began in 1986 and to increase dairy farmers income looking at investment to increasing milk production. The price control policy did not prove to be effective: a) consumers did not increase their milk consumption because of inflation in other household areas; b) larger dairy farmers did not increase their profits because the costs for milk production (especially the cost of the feedstock) increased; and c) many small dairy farmers were unable to afford the costs of integrating the technologies needed to improve the volume and quality of milk to the standards demanded by the large firms. Instead, they sold their milk to artisan cheese producers (del Valle Rivera 2000).

It was not until 1996, following NAFTA, that the price of pasteurised milk and the price paid to farmers were de-regulated and substantial increases in milk production were achieved (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000). However, regions responded at different speeds. For instance, La Laguna region (and the arid and semi arid regions) outperformed Jalisco and Tabasco (the temperate and tropical regions) (see Figure A2).

[5] The Pact for the Stability and Economic Growth (Pacto para la Competitividad y el Empleo, PECE 1987) and the Alliance for the Recovery of Economic Growth (Alianza para la Recuperación y Crecimiento Económico, 1995) were agreements between government, labour and the private sector and combined austere fiscal and monetary restraints with price/wage controls and fewer trade restrictions (del Valle Rivera 2000).



Source: Author's elaboration of data from SAGARPA (2000; 2005).

Figure A2 Rates of change in milk prices paid to farmers and milk production (1994-2004)

b) Development policies

Historically, the policies addressing development of milk production started in the 1950s when the government promoted the specialised milk production systems in La Laguna (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000; Salas Quintanal 2002). This was a regional project that attempted to mitigate the damage to the agriculture of La Laguna due change in the international price of cotton, which had been the main agriculture activity in the region since the Mexican Revolution (see the case of La Laguna region, Chapter 5, section 5.1). In the tropical regions, a 1970s project in La Chontalpa region, in the state of Tabasco targeted milk production to mitigate poverty and malnutrition in the indigenous population (Aranda Ibáñez 2005).

More recently, in response to the technological disadvantages of the agriculture sector when Mexico joined to GATT, first SAGAR and later SAGARPA developed a series of policies to mitigate the negative effects on the price of basic crops.[6] The Federal

[6] There is ongoing debate about whether PROCAMPO/Alianza para el Campo was a direct policy subsidy to farmers to compensate for the high subsidies received by the foreign suppliers of NFDM and about the pros and cons of agriculture subsidies more widely. According to Marín López 1997; 1999; Mexican milk production was less protected by the Federal government compared with dairy sectors in the US and EU. However, there is no clear understanding by US society and politicians about the extent of the effect on agricultural production (i.e. supply of food) and the income of the farmers in the developed and developing countries, if these subsidies were to be dismantled (Becker 2002; Beitel 2005; Preble, Slivinski et al. 2006).

government provided aid through a support programme Programa de Apoyo para el Campo, PROCAMPO (1986). In 1995, PROCAMPO changed its orientation from direct subsidies to farmers to a development-oriented programme called Alianza para el Campo[7]covering five normative drivers for development: agriculture, livestock, rural, animal and plants health and technology transfer (SAGARPA 2000).

PROCAMPO/Alianza para el Campo influenced the MDS via two programmes, aimed at: a) milk self-sufficiency (i.e. Programa de Transición hacia la Autosuficiencia Lechera, PROTAL, 1989); and b) increasing milk production and reducing imports of NFDM (i.e. Programa de Producción de Leche y de Sustitución de Importaciones, PLSI, 1996-2000). PROTAL helped to import specialised Holstein cows to repopulate the herds in the intensive systems, and to import semen and embryos for the development of Holstein-Zebu crossbreeding for dual-purpose systems. The overall result was that milk production increased in the intensive systems (del Valle Rivera 2000, p 349).

The PLSI had specific technology transfer strategies supported mainly by INIFAP aimed at a) improving herd genetics, b) increasing supply of feedstock (i.e. development of crops and grazing land), c) supporting integration of farmers with dairy processors through training programmes (e.g. GGAVATT and DEPAI groups), and d) supporting animal health campaigns (Peralta Arías and Lastra Marín 1999; del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000).

Since Federal government, state governments and farmers provided resources for PROCAMPO/Alianza para el Campo, small farmers had limited participation because they could not afford the contribution required to participate in the development programme. Furthermore, in many cases the resources turned to be a direct subsidy to the lowest income farmers but also benefited large producers (Ekboir, Espinosa García et al. 2003)[8]. The result again of the PLSI was increased production in the intensive systems (del Valle Rivera 2000).

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[7] Alianza para el Campo became Alianza Contigo in 2003 and was a programme that supported agriculture rural development http://senasicaw.senasica.sagarpa.gob.mx/portal/html/senasica_principal/alianza_contigo/PAC_2003_REGLAS_OPERACION_DOF_250703.pdf (June 25, 2006).

[8] PROCAMPO/Alianza para el Campo favoured large milk producers because they were better placed economically to access resources from government financial organisations (i.e. FIRA, FIRCO and Financiera Rural). Furthermore, large dairy farmers dominated cattlemen’s associations in the specialised

In the case of the integration of dairy farmers and dairy processors to provide chilled milk, policy implementation implied different actors' participation. In the northern regions farmers worked 'independently' of government and were led by large domestic firms, but in Jalisco, Michoacán and Guanajuato, government policies supported 'Tanques Rancheros' programme to set up the chilled tanks network in the late 1980s (McDonald 1997; Rodríguez Gómez 1998a; Rodríguez Gómez 1998b; McDonald 1999; Cervantes Escoto, Alvarez Macías et al. 2001; McDonald 2001). In the southeastern region, Nestlé led the integration for the collection of the raw fresh milk (del Valle Rivera and Alvarez Macías 1997).

Another effort of SAGARPA to provide incentives to increasing productivity and competitiveness in dual-purpose systems was PROGAN (i.e. Programa de Estímulos para la Productividad Ganadera) set up in 2003, to provide resources for cattle farmers (Mateos Payro 2005). This programme aimed at creating a livestock data control system (e.g. genetics, productivity and animal health control) to improve cattle planning programme and to enable the traceability of the livestock products including dairy in the long-term (i.e. Sistema Nacional de Identificación Individual de Ganado, SINIIGA). However, lack of resources and trust among cattlemen, suspicious that government would impose higher taxes on them, have limited PROGAN achievements. Furthermore, the planning process is still based on models rather than data from individual farms (Alvarez Macías 2005).

Government stakeholders have questions whether the Alianza para el Campo policy has improved the productivity and competitiveness of the agriculture sector. In 1998, SAGARPA agreed to carry out an annual assessment with FAO (i.e. FAO-SAGARPA assessment procedures UTF/MEX/0A0/MEX and UTF/MEX/0A5/MEX) at two levels - country and state, under the sub programme of research and technology transfer (Subprograma de Investigación y Transferencia de Tecnología, SITT, which is part of SNITT, see subsection 1.2). This qualitative assessment identifies the influence of the resources applied (e.g. INIFAP, Fundaciones Produce projects, etc.) (Alvarez Macías

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dairy regions (e.g. La Laguna), which lobbied government on policy on behalf of the dairy farmers. The situation is different in other regions (e.g. Jalisco and Tabasco), where beef cattlemen dominate cattlemen's associations.

2005), but it does not measure the creation of capabilities on farms (Luévano González 2005).[9] Therefore, the assessment neither provides better indicators of competences creation in the agriculture system nor does it facilitate the policy making process (Alvarez Macías 2005).

In the case of milk production, it has been argued that PROCAMPO/Alianza para el Campo significantly influenced productivity per cow and the integration of the value chain in specialised systems (e.g. La Laguna dairy regions in the arid and semi arid regions). However, there is little evidence of much impact in dual-purpose systems (e.g. Tabasco dairy region) (del Valle Rivera 2000; del Valle Rivera 2005; Luévano González 2005).

In addition to the incoherence of agriculture policies, there have been limited resources allocated to the agriculture sector (Ekboir 2005), which, in the period of analysis, showed a significant decrease in the overall supply of resources to the programme (see Table A1). This opens question about whether the dysfunction in the MDS could be ameliorated if more resources were allocated to the system to catch up in productivity and competitiveness in milk production.

Table A1 Changes in supply of economic resources for Alianza para el Campo

Year	Current Mexican Pesos, millions	Producer index prices	Constant Mexican Pesos
1995	5864.00	37.18	157.72
1996	6793.40	52.65	129.02
1997	7533.00	60.29	124.95
1998	8491.70	71.60	118.61
1999	9372.20	80.03	117.10
2000	10378.90	78.19	132.74
2001	11004.60	85.96	128.01
2002	11850.50	90.17	131.42
2003	13110.70	94.66	138.50
2004	13810.00	106.30	129.91
CAGR 1995-2004			-2.13

Sources: Author's estimations with of data from the 6th Government Report, Sexto Informe de Gobierno, 2006[10].

[9] There was one example in Tabasco, where implementation of the SAGARPA-FAO assessment has allowed a better understanding of the benefits of Alianza para el Campo (Abreu Vela 2005; Alvarez Macías 2005).

[10] Banco de México website:
http://www.banxico.org.mx/polmoneinflacion/estadisticas/indicesPrecios/indicesPreciosProductor.html
(August 20, 2008).

In addition to its agriculture policies, the Mexican government made substantial legal changes to land ownership in 1992 to promote private and foreign investment in agriculture. Many rural producers, mainly ‘ejidatarios’, became owners of their land. However, this action has not been enough to create incentives to improve production because of the accumulated technological disadvantages that del Valle Rivera (2000; 2005) attributes to the lack of government support to small producers, dating back to the middle of the 1960s. Moreover, Alvarez Macías (2005) concludes that the government was not willing to support the agriculture or any other industrial sector. Instead, it supported the financial sector, which proved not to be able to overcome the substantial rise in world interest rates and external current account deficit financed by short-term capital inflows, and the Peso devaluation at the end of 1994 led to a financial crisis that negatively affected the whole economy.

Since 2000, with the change in political party, PRI (which had ruled the country since 1917) and under the Rural Development Law promulgated in 2001, SAGARPA created committees aimed at the integration of the economic actors involved in the production chains of the main agriculture and livestock products (Villamar Angulo 2005). Currently, the committee for the system of milk and dairy production (i.e. Comité para el Sistema Producto Bovino Leche, CSPBL) is constituted by 65 representatives from private and public dairy organisations, which hold permanent consultant forums to establish a common vision and to set up the strategies to increase the productivity and competitiveness of the MDS.

In summary, PROCAMPO and Alianza para el Campo have supported the development of agriculture via subsidies for the acquisition of selected technologies, which have been imported and transferred mainly by INIFAP. These programmes have posed several problems. First, they were imposed by Federal government with little consultation with users and without analysing regional needs (Ekboir 2005). Second, the programmes focused on technology transfer through the purchase of machinery and equipment for agriculture with little attention to developing farmers’ capabilities for effective technology transfer and use (Ekboir, Espinosa García et al. 2003; Alvarez Macías 2005; Ekboir 2005; Luévano González 2005). Third, extension activities carried out by INIFAP transferred knowledge in one direction, from extension agents to farmers, with no feedback from farmers to researchers on regional needs (Alvarez Macías 2005;

Cervantes Escoto 2005). Fourth, the success of the programmes was measured solely in terms of the number of farmers who had benefited from the allocated resources (e.g. number of tractors, systems of irrigation, etc.), and thus did not take account changes in capabilities resulting from the programmes (Abreu Vela 2005; Ekboir 2005). The mixed results led to a debate about whether the policy is responsive to the needs of farmers (Alvarez Macías 2005; Cervantes Escoto 2005; Chombo Morales 2005; Rodríguez Gómez 2005).

1.2 Mexican agriculture research system, SNIA

With the introduction of NAFTA, there was a restructuring of the national system for research and technology transfer for rural sustainable development (Sistema Nacional de Investigación y Transferencia de Tecnología para el Desarrollo Rural Sustentable, SNITT) under the 2001 Law for Sustainable Rural Development. This aimed at linking R&D organisations with farmers for rural sustainable development. Activities addressed technological development in farms and its validation, incentives to adopt technologies and engage in technology transfer by farmers (e.g. DEPAI and GGAVATT groups) (Ekboir, Espinosa García et al. 2003).

SNITT is supported by a very complex structure of organisations, institutions and programmes,[11] i.e. the Mexican system of agriculture research (Sistema Nacional de Investigación Agropecuaria, SNIA). It has been argued that Mexico does not have a 'formal system'[12] to coordinate agriculture research activities, which is seen as a main failure of the agriculture research system (Ekboir, Espinosa García et al. 2003, p 19).

According to Ekboir, Espinosa García et al. (2003) there is *de facto*[13] a SNIA[14] constituted of five main entities (see below Figure A3):

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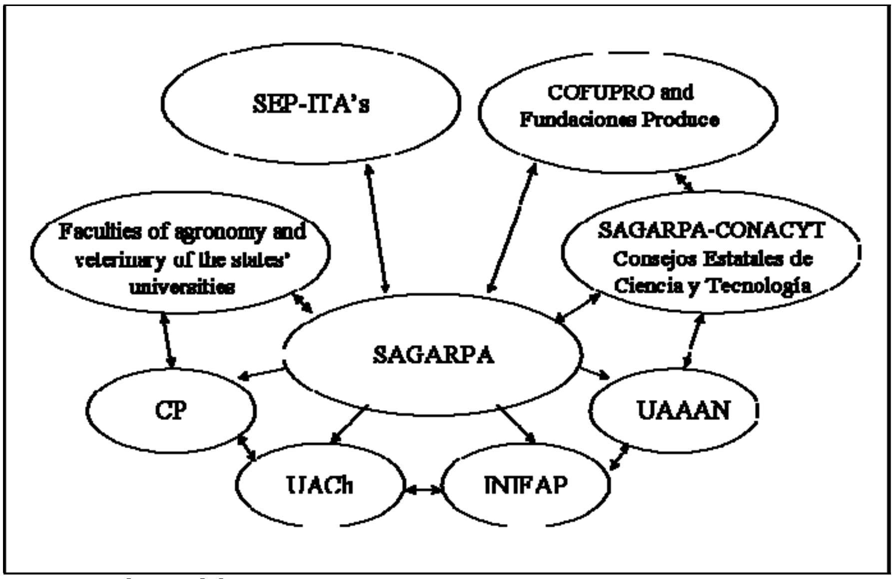
[11] For information on SNITT, see http://www.snitt.org.mx/concepweb.html#top (September 25, 2007).
[12] This can be translated as a dysfunctional system.
[13] It means that research institutes and universities interact to carry out agriculture research (Ekboir, Espinosa García et al. 2003, p 19).
[14] The difference between SNITT and SNIA is that SNIA includes the ITAs and the faculties of agronomy and veterinary of the state universities as part of the system of agriculture research.



Source: Author's elaboration.

Figure A3 Mexican agriculture research system, SNIA

a) SAGARPA and its national institute for research in forestry agriculture and livestock, INIFAP [15] (i.e. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias), and its agriculture universities, the Universidad Autónoma de Chapingo (UACh)[16], the postgraduate agriculture college, CP or COLPOS [17] (i.e. Colegio de Posgraduados), and the Universidad Autónoma Agrícola Antonio Narro (UAAAN);[18]
b) the faculties of agronomy and veterinary of the state universities;

[15] In the 19th century, Mexico had schools and universities in agriculture, veterinary and agrarian subjects. However, modern agricultural research did not start until the mid of the 20th century. In the 1940s, Cardenas's government set up the Oficina de Estudios Especiales (i.e. Office for Special Studies); which was cooperation between the Mexican Secretariat of Agriculture and Livestock and the Rockefeller Foundation to establish the Institute of Agriculture Research, and the Institute for Livestock Research. In the 1950s, Federal government set up the Institute for Forestry Research and the Postgraduate College in Agriculture (i.e. Colegio de Posgraduados, CP). In 1962-63 the Oficina de Estudios Especiales and the Research Institutes in Agriculture, Forestry and Livestock joined to become Instituto de Investigaciones Pecuarias (i.e Institute of Livestock Research), which turned out INIFAP in 1985 (Ekboir, Espinosa García et al. 2003).

[16] UACh was founded in 1854 as a national college for agriculture (Escuela Nacional de Agricultura) and became a university in 1978. It is the oldest and largest agriculture and agrarian university in Mexico and is located in Texcoco, in the state of Estado de México.

[17] COLPOS is the UACh postgraduate research unit since 1959 and became an independent research centre in 1978. COLPOS and INIFAP became a public research centres in 2001. UACh is located in Texcoco, in Estado de México, but has campuses in other states.

[18] UAAAN was founded by the philanthropic Narro family, and became part of Coahuila State University in 1923. It has two campuses located in La Laguna region, Buenavista and Saltillo in Coahuila. It specialises in agriculture and undergraduate and postgraduate in agriculture, animal husbandry and agro economics subjects.

c) the agriculture colleges, Institutos Tecnológicos Agropecuarios (ITAs) within the Secretariat of Education (SEP);[19]
d) the states Council for Science and Technology (i.e. Consejos Estatales de Ciencia y Tecnología within CONACYT); and
e) the patronage for agriculture research, Patronato de Apoyo a la Investigación Agropecuaria (COFUPRO) and its states' organisations, i.e. Fundaciones Produce, with the participation of farmers to define priorities of the agriculture research.

SAGARPA coordinates SNIA under the SNITT, and SITT provides the economic resources from Alianza para el Campo, which are complemented by agriculture trusteeship of SAGARPA-CONACYT to support research in universities, INIFAP, and firms. Overall resources for funding agriculture research were reduced to 5.5% of CONACYT's total expenditure in 2005: in 1995, funding was 11% of expenditure (CONACYT 2006).

SAGARPA-CONACYT funds are allocated by competitive bid but in 1995 to 2005 around 90% of resources went to INIFAP projects and the agricultural universities and very little to other organisations (Ekboir, Espinosa García et al. 2003; CONACYT 2006).

To capture local demand for agriculture research, CONACYT has 13 states centres (i.e. Consejos Estatales) integrated in a network with INIFAP, Fundaciones Produce and the SAGARPA state offices. However, this coordination has not achieved a better distribution of economic resources or increased private investment in agriculture (Ekboir, Espinosa García et al. 2003).

The limited resources and multiparty participation in decision making within a hierarchical system restricts regional decision making to guide research (Ekboir, Espinosa García et al. 2003; Ekboir, Dutrénit et al. 2006). These structures, linkages and institutions have at times favoured and/or constrained the evolution of capabilities at the regional level.

[19] SEP is Secretaría de Educación Pública.

a) INIFAP, technology transfer mechanisms and agriculture universities

Public research was part of ISI policy and changed little up to the mid 1990s. INIFAP is the main and largest agriculture research organisation in the country.[20] INIFAP together with CP, UACh and UAAAN, aimed to respond secretariat of agriculture education and research demand and did have limited capacity to operate its own research programmes. It designed research and education models along the linear model of science, instead of entering long-term commitments with specific development projects (Ekboir, Espinosa García et al. 2003). Its hierarchical structure and lack of incentives did not allow to create strong relationships with farmers and/or agro industries (Solleiro and Pérez Jerónimo 1999) and the quality of the communication between researchers and users has been described as persistently inadequate (Casas and Luna 1997; Solleiro and Pérez Jerónimo 1999; Casas, de Gortari et al. 2000). This is what constitutes the national system of researchers (Sistema Nacional de Investigadores, SNI).[21]

SNI rewards researchers and professors with good publications records in terms of high impact scientific journals and books (Aranda Ibáñez 2005; Medina Alvarez 2005; Vázquez Gómez 2005). However, it does not reward technology transfer (i.e. third stream university activities) (Ekboir, Espinosa García et al. 2003). A recent reform in the SNI reward system promoted the diffusion of technology and innovation activities; but results have been limited and complementing factors and incentives need to be present for SNI to succeed (Ekboir, Espinosa García et al. 2003; Vázquez Gómez 2005).

Under pressure from the neo liberal economic project (and we would argue the shortage of Federal resources because of the recurrent economic crises), competitiveness and economic sustainability become main aim of INIFAP (Ekboir 2005; Medina Alvarez 2005; Vázquez Gómez 2005). However, SAGARPA could not afford to fund fully INIFAP and in 2001, prompted INIFAP to become a public research centre. This gave

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[20] In 1998, INIFAP had approximately 1,300 researchers and technicians located in 6 regional research centres organised by discipline and 81 experimental stations with approximately 100 agriculture programmes, 60 forestry programmes and 20 livestock programmes. It once had the largest budget allocated by the Federal government from PROCAMPO and Alianza para el Campo projects (Ekboir, Espinosa García et al. 2003).

[21] SNI was created by decree in 1984 to support the upper layer of the better qualified and most productive researchers, providing a substantial supplement to their income because of the economic crisis unleashed in the early 1980s by the fall in petroleum prices, and the severe inflation which caused a drastic reduction in real salaries. It rewards mainly academic work, rather than diffusion of research and knowledge (Vázquez Gómez 2005).

INIFAP autonomy to seek funding and to operate its own budget and research programmes. SAGARPA funds fixed costs and INIFAP has contracts with Fundaciones Produce and any other party, which in the past was not possible. INIFAP is involved in helping links between farmers (i.e. a demand driven technology innovation model) (Paredes and Moncada 2001). Some of its research processes and routines have changed to strength the relationship with farmers, which have created some economic incentives for researchers to interact with users under the DEPAI programme and to encourage the use of GGAVATT to transfer INIFAP technology to support farmers' development (Barradas Lagunes 2005; Medina Alvarez 2005; Vázquez Gómez 2005). However, as already mentioned, it still receives its operational budget from government (i.e. SAGARPA-CONACYT) and its impact is difficult to assess. INIFAP is faced with an ageing generation of researchers, who were recruited during the boom of the Green Revolution, 1960-1985, and has been unable to attract younger people due to lack of resources (Medina Alvarez 2005; Vázquez Gómez 2005).

Regarding technology transfer activities, SAGARPA has DEPAI, which is the largest integrated extension activity (i.e. Desarrollo de Proyectos Agropecuarios Integrales, DEPAI) [22]. DEPAI provides technical assistance and technology transfer through its trained extension agents to farmers and cattlemen, which some of whom use the GGAVATT method[23].

GGAVATT is a method developed for validation and technology transfer from INIFAP to cattle farmers. It is part of INIFAP's national programme for technology validation and transfer (PRONAVATT, Programa Nacional de Validacion y Transferencia de Technología) under SNITT (Alvarez Macías 2005).

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[22] A DEPAI group consist on to set up strategic planning projects of farmers belonging to a small group of dairy farmers coordinated by a DEPAI's extension agent. They together develop a vision for the future of each of the units of production and the activities required reaching it. It is a two-way learning process. It starts with a two-day session. The first day's activities focus on diagnosing: a) animal health, production and nutrition, b) technology use, c) supply chain of inputs for production, d) finance management, and e) business development, on the farm. The second day focuses on improvement activities: a) using the diagnostic to detect problems and needs, b) the setting of priorities to solve problems, and c) agreement on actions between the farmers and extension agent to achieve the aims. DEPAI's extension agents and dairy farmers do monthly assessments of the achievements within the units of production for at least the following two years (Arellano Leaño 2005; Valencia Zarazúa 2005).

[23] It was estimated to have approximately 1,200 extension agents, 20% of them working with livestock production using the GGAVATT method (Alvarez Macías 2005).

The GGAVATT method (Galindo González 2001) was developed by an INIFAP Veracruz research group in La Posta, Paso del Toro research station in Veracruz state in the early 1980s (Pérez Saldaña 2005). It aims at to increase the capabilities of groups of cattle farmers working together with extension agents to improve their productivity to make their farms economically and ecologically sustainable (Román Ponce 2005).[24] INIFAP La Posta together with SAGARPA state offices, the associations of cattlemen, supported by the University of Veracruz and the professional association of veterinarians (i.e. CEMVZV) have trained extension agents from DEPAI and other organisations to implement GGAVATT method around the country (Alpírez Mendoza 2005; Blanco Ochoa 2005; Valdovinos Terán 2005; Zilli Debernardi 2005).

The GGAVATT method has been one of the most successful technology transfer processes to develop capabilities in farms[25] in tropical regions[26] and became the official technology transfer method in the state of Veracruz (Remes Cabada 2005; Ruíz Arriaga 2005). Around 60% of the groups using the GGAVATT method are dual-purpose dairy farmers and 10% are specialised and semi-specialised dairy farmers. However, diffusion of the use of the method has been difficult because of the limited number of extension

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[24] According to Galindo González (2001), the GGAVATT method follows four stages. The first stage involves the formation of a GGAVATT group of up to 20 farmers and an extension agent (or DEPAI agent). Together they find the problems on farms operations, agree solutions and make commitments to implement the solutions. Second, they apply the technological package provided by the extension agents and establish economic and productions records to follow up in every unit of production. These stages last between 12 to 14 months. Third, the extension agent carries out intensive training on the adoption and implementation of the technological package provided by INIFAP. The overall project lasts for two to three years more. Fourth, at around the fifth year of the GGAVATT group work, farmers carry out specific activities for commercialisation and look at capital investment. Farmers commit to following at least 70% of the practices suggested by the extension agents and to recording their activities to improve their decision-making.

[25] According to Román Ponce (2005) some of the mechanisms that develop capabilities are: a) collective learning by sharing experience among the members of the groups to create endogenous knowledge; b) imitating best practices from advanced farmers; c) codifying information that helps to control the technological processes within farms; d) multiple feedback loops for learning, from the researchers and extension agents to the members of the group and vice versa; e) speeding up the decision-making processes to implement changes in farms; f) self-driven developing processes supported by shared values (e.g. trust, help, imitating); and g) committing and delivering results to encourage other group members to imitate and improve their farms' practices.

[26] E.g., the emergence of JAMALAC, a dairy processor, was the result of organizing to improve the productivity of the cows of dairy farmers in Cotaxta in the state of Veracruz (Alonso Capetillo 2005; López López 2005); and the dairy farmers of the Asociación Ganadera Local de Ozuluama, AGLO (2005) in the state of Veracruz reports that farmers have improved the productivity of the cows from 1-3 litres per day to 10-13 (del Angel Juárez, Molina del Angel, et al. 2005).

agents (one to every 20 farmers) and limited budget[27] to train agents to assist farmers (Vázquez Gómez 2005).

It has been argued that GGAVATT has limitations such as the difficulty to systematically assess the results because of the long-term of the learning process (2-5 years). Another limitation is updating knowledge of the extension agents to attend to the demands of farmers (del Angel Juárez, Molina del Angel et al. 2005; González Díaz 2005; Lagunes Ortega 2005). The most important limitation however, is that it does not include the development of capabilities to commercialise products (Alvarez Macías 2005; del Valle Rivera 2005).

Regarding the agriculture universities, according to Ekboir, Espinosa García et al. 2003, Mexican university system (which includes UACh, CP and UAAAN) has followed the organisation of the European universities. Professors are not obliged to interact with users. Their main contribution to MDS development has been the development of human resources through their higher education and doctoral research programmes. For instance, CIESTAAM [28] (part of UACh) has a doctoral research programme in agribusiness, which includes research in milk production in temperate regions (Cervantes Escoto 2005). CP has a regional research centre in Cárdenas campus in Tabasco to attend the local research demands in milk production in tropical regions (Aranda Ibáñez 2005). UAAAN, on the other hand, besides its agriculture and veterinary faculties, it has devoted long-term research to the economics and management of milk production in La Laguna region in cooperation with the dairy cattlemen's association (UGR La Laguna) (Aguilar Valdés 2005; Alvarado Martínez 2005; Luévano González 2005).

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[27] Exceptional cases of farmers' organisations to export fruits and vegetables succeeded in importing technologies and organising commercialisation channels, without government support (Ekboir, Espinosa García et al. 2003).

[28] CIESTAAM (Centro de Investigaciones Económicas, Sociales y Tecnológicas de la Agricultura y la Agroindustria Mundial) is the economic, social and technological research centre for world agriculture and agro industry located in Texcoco, Estado de Mexico. It is part of UACH. UACH although it has a research site in Bermejillo, Durango, it does not do research in milk and dairy production in arid and semiarid regions (Cervantes Escoto 2005).

b) State agronomy universities and veterinary faculties

Besides UACh, CP and UAAAN, there is a national group of faculties of agronomy and veterinary medicine in the state universities estimated to number 122 in 1998 (Ekboir, Espinosa García et al. 2003), which run higher education programmes (masters and doctoral programmes) but very few in dairy processing (Pérez-Gavilán Escalante 1997). Nevertheless, exceptional contributions have been made in animal health and husbandry at the UNAM[29] and Universidad Veracruzana (Blanco Ochoa 2005; Zilli Debernardi 2005) and in the economics (del Valle Rivera 2000) and sociology of milk production at the UNAM (Martínez Borrego and Salas Quintanal 2002; Salas Quintanal 2002; Martínez Borrego and Salas Quintanal 2002a), UAM, Ixtapalapa and Xochimilco[30] campi (Alvarez Macías 2005), and CIESAS Occidente[31] (Rodríguez Gómez 1998a; Rodríguez Gómez 2005), and forage production[32].

In the case of milk processing, around 25 universities and research organisations carry out research as part of their research programmes in food technology,[33] although very few have specialised in improving dairy processing[34] (González Padilla 1999; Polanco Jaime and Chiwo Gallegos 1999). For instance, the centre for research and technology assistance in Jalisco, CIATEJ (i.e. Centro de Investigacion y Asistencia Tecnológica del

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[29] UNAM is Universidad Nacional Autónoma de México, the Autonomous National University of Mexico, the largest public university. It has two faculties, where it carries out most of the research in veterinary science.

[30] UAM is Universidad Autónoma Metropolitana, the Metropolitan Autonomous University with higher education programmes and research in veterinary and social science located in Mexico City.

[31] CIESAS is Centro de Investigaciones y Estudios Superiores en Antropología Social. It is one of five research centres in social anthropology founded in 1973 by CONACYT.

[32] Note that there are important spillovers from grain production research carried out by the international research centre for the improvement of the technology for the production of maize and wheat, CIMMYT (Centro the International para el Mejoramiento del Maíz y del Trigo). CIMMYT is one of 15 centres of the Consultative Group on International Agricultural Research (CGIAR), which is a strategic alliance of international and regional organisations, and private foundations supporting agricultural research systems and civil society organisations including the private sector. The alliance mobilises agricultural science to reduce poverty, foster human well being and agricultural growth and protect the environment. CIMMYT is in Mexico as part of the Rockefeller programme under the Green Revolution in 1963. It had a predecessor established in 1943. Analysis of grain and forage production, although very important for the development of the MDS, is beyond the scope of this research.

[33] E.g. UNAM, Facultad de Estudios Superiores Cuatitlán, ITESM, Universidad de Guadalajara, Universidad Autónoma de Chiapas, Universidad Autónoma de Sinaloa, and Universidad Autónoma de Querétaro.

[34] They are Centro de Desarrollo Tecnológico para la Industria Láctea, CDTIL in the state of Chihuahua, Centro de Innovación y Desarrollo, CID in the state of Sonora, Centro de Investigación en Ciencia y Tecnología de Alimentos in the state of Hidalgo, and Instituto de Agroindustrias de la Mixteca in the state of Oaxaca.

Estado de Jalisco) has a research programme for the production of regional cheeses ‘Cotija’ in the temperate area of Michoacán and Jalisco states (Chombo Morales 2005; del Valle Rivera 2006). It has worked with artisan cheese producers and private organisations (e.g. Fundacion Tabasco) in Tabasco to improve endogenous technologies to produce ‘de Poro’ cheese (Chombo Morales 2005).

c) ITAs within SEP

As part of the general agriculture education, SEP has a department for agricultural college education (i.e. Dirección General de Educación Tecnológica Agropecuria, DGETA), with colleges around the country, that focus on the education of agricultural technicians. Its programmes have been criticised because they do not respond to regional needs (Aguilar Valdés 2005; Aranda Ibáñez 2005).

d) Fundaciones Produce and COFUPRO

Fundaciones Produce (i.e. foundations for agriculture production) are non-profit agricultural producers’ organisations. They were set up under Alianza para el Campo in 1995 in each state (i.e. 31 associations).[35] They are innovative, participatory approaches within a demand driven technology innovation model administered by the producers. They aim to enhance linkages between agriculture producers, INIFAP, research institutes and universities (i.e. user-producer relationship) to foster technology transfer and to contribute to the design of sectoral/regional innovation policies for the socio-cultural and environmental sustainability of agriculture in all the states (Paredes and Moncada 2001; Ekboir, Dutrénit et al. 2006; Wennink and Heemskerk 2006).

Fundaciones Produce have a trust fund, which includes a mechanism for matching funds between the Federal and state governments, and agricultural producers, the private sector. Their research agenda and accountability are to attend state needs but results are uneven (Paredes and Moncada 2001; Ekboir 2005; Ekboir, Dutrénit et al. 2006).

In 1997, the Presidents of Fundaciones Produce established national and international level forums called COFUPRO (i.e. Coordinadora Nacional de Fundaciones Produce) to institutionalise user-producer research processes. COFUPRO and Fundaciones Produce

[35] SITT supplies economic resources to carry out technology transfer projects in the different states through Fundaciones Produce.

developed joint projects with researchers from INIFAP, universities, FIRA and CONACYT. Some of these projects have been responsive to producers' needs (Ekboir, Dutrénit et al. 2006). For instance, in La Laguna, the trust for milk production research, PIAL, has improved alfalfa yields (Iruzubieta Quezada 2005; Nuñez Hernández 2005). However, it has been argued that Fundaciones Produce have not succeeded in raising private investment in R&D. Furthermore, among private actors and researchers there is a belief that government should provide more resources, because what is on offer is not enough for what the regions and country need (Aguilar Valdés 2005; Ekboir 2005; Luévano González 2005; Ekboir, Dutrénit et al. 2006). It also has been argued that this allows large producers to match the funds to their demands and discriminate against smaller farmers (Aguilar Valdés 2005; Luévano González 2005).

In summary, efforts to improve the diffusion of agriculture research, although numerous, still fall short of reaching the ultimate user. In general, poor resources (i.e. research budget and low numbers of extension agents) have been a major problem, and the research agenda seems to be aligned to the aims of SAGARPA. Consequently, agriculture research still does not fulfil farmers' needs and dairy processing seems no having government efforts for innovation.

1.3 Financial organisations supporting the MDS

Besides the commercial banks[36] and PROCAMPO/Alianza Para el Campo, Mexico has specific government financial organisations supporting agriculture and agro business. They are FIRA, Financiera Rural and FIRCO, which provide economic support to dairy farmers and dairy firms through commercial banks (85%) and regional credit unions (15%) (Austin, Chu et al. 2004).

FIRA is Fideicomisos Instituídos en Apoyo a la Agricultura. It is the oldest trusteeship for agriculture development within the Mexican central bank (i.e. Banco de México) (founded in 1954). It provided credit and guarantees, extension services, training as well as technology development and transfer to agro industry and fisheries sectors, and was

[36] Most large and medium sized banks have operations with dairy farmers and dairy processors. However, it seems that BANORTE has one of the largest operations in the north of the country to support agriculture development, perhaps because the owner of BANORTE also owns GRUMA, the largest producer of corn meal and tortillas, the main staples in the Mexican population.

considered one of the most successful agricultural development organisations. To respond NAFTA, in 199A, FIRA began a transformation process (similar to INIFAP) to becoming a private financial organisation by 1998.[37] Along with this transformation, FIRA created specific financial derivatives instruments,[38] suited mainly to large farmers and agro industries (Cabello Villarreal 2005; Fernández Palacios 2005). Whereas in the 1990s most of the FIRA's resources were allocated to farmers, by 2003, they were allocated to large agro industries (e.g. Cervecería Cuauhtémoc-Moctezuma, Tyson México and GRUMA) (Austin, Chu et al. 2004). Furthermore, FIRA no longer participates in technology transfer programmes (Ekboir, Espinosa García et al. 2003; Cabello Villarreal 2005; Esquivez González 2005; Iruegas Evaristo 2005). The development activities for small farmers that FIRA carried out until 1994 were taken over by Financiera Rural and Alianza para el Campo, and training programmes by DEPAI and GGAVATT groups using resources from Alianza para el Campo (Esquivez González 2005; Iruegas Evaristo 2005).

The new FIRA financial mechanism called the value network model[39] has been used for some dairy processors. For instance, Sigma Alimentos and Nestlé as 'para financieras'[40] (i.e. financial intermediaries) (Ortíz 2005) have supported small dairy farmers to acquire resources from FIRA and other banks to buy specialised cows (Falcón Estrada 2005), and to update milking and chilling systems (Cabello Villarreal 2005; Iruegas Evaristo 2005; Ortíz Vera 2005).

In the case of Financiera Rural, which is a decentralised government financial organisation (i.e. a first-tier rural credit organisation), emerged in 2002 after BANRURAL (the former government's agriculture bank) went into liquidation. Financiera Rural has promoted the creation of infrastructure on farms, training programmes for producers and the development of financial rural intermediates (i.e.

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[37] Originally, FIRA received annually subsidies from the Mexican government. In 1998, as part of a government reorganisation, the subsidies ended. Henceforth, FIRA's programmes would be self-financed. Banco de Mexico made a one-off loan to FIRA, due to be paid back in 2013 (Austin, Chu et al. 2004).

[38] E.g., the swap programme integrated guava and avocado farmers to export in Michoacán. An interest rate swap is a contract between two parties in which one party agrees to pay the other a variable interest rate in return for a fixed interest rate, based on specific nominal amount and for a specified period of time (Austin, Chu et al. 2004, p 9).

[39] The value network model entails all the related industries and services that directly affect the competitiveness of the agro systems, farmers, cattlemen and agro business (Iruegas Evaristo 2005).

[40] 'para financiera', i.e. agribusinesses serving as lenders to complement financial organisations' arrangements (e.g. SIGMA Alimentos and Nestlé).

Intermediarios Financieros Rurales, IFR) for commercialisation of products (Austin, Chu et al. 2004).

FIRCO is Fideicomiso de Riesgo Compartido, a trusteeship for rural development created in 1981 by the Secretariat of Agriculture, SAGAR. It is an instrument of the rural development policy, which provides complementary resources to minimise the risk for new agribusiness projects (e.g. entrepreneurships) and established ones aimed at the integration of rural producers and diversification of their production.

FIRA has supported successfully specialised and semi-specialised milk production systems (e.g. La Laguna and Los Altos regions), while FIRCO and Financiera Rural have supported very few projects in tropical regions (e.g. the production of dairy products by JAMALAC[41]) (Alonso Capetillo 2005; López López 2005) and the integration of dairy farmers and dairy processors by Fonterra-Nestlé in Veracruz (Ortíz Vera 2005; Valdivia Valentín 2005).

1.4 LICONSA and its complex role in the MDS

LICONSA is a state firm, established in 1963 to re-hydrate NFDM to produce 'pasteurised milk' to be distributed to poor families to mitigate malnutrition, under the social programme of CONASUPO. CONASUPO was dismantled in 1999 and LICONSA was reformed[42] and put under the Secretariat of Social Development (i.e. Secretaría de Desarrollo Social, SEDESOL).

The role of LICONSA has been complex and not well understood by other actors in the MDS, which has made it a subject of criticism from many politicians and scholars (Aragón Mladosich and Gómez Ibañez 2004).

a) LICONSA and its social programme

[41] JAMALAC was set up with farmers' resources, and resources from Alianza para el Campo, for modernisation of milk production; and FIRA and FIRCO for the construction of dairy facilities (Alonso Capetillo 2005).

[42] LICONSA is regarded as a reasonably well managed with low levels of corruption (Aragón Mladosich and Gómez Ibañez 2004).

From its foundation to 2005, LICONSA has imported NFDM for two purposes: a) production of liquid milk for its social programme; and b) supply of NFDM to private firms under quota agreements.

In 2005, LICONSA had 10 facilities across Mexico[43] where approximately 85% of its NFDM is rehydrated, supplemented with vegetable fat and other nutrients (i.e. vitamins, salts, etc.), pasteurised and packed as liquid milk in plastic bags, for consumption within two or three days, the remaining 15% of NFDM being re-packaged in multi-foil sachets (Sáinz Picos, Castillo Herrera et al. 2005). These products are distributed in urban areas through special shops run by DICONSA.[44] Of interest in this value chain is the management of the distribution system so as to retain the quality of the product. LICONSA has no chilling systems to transport its products, has nor DICONSA chilling storage.[45] LICONSA also produces UHT milk for schools and children's breakfast programmes[46] (i.e. Desarrollo Integral de la Familia, DIF) (Gundersen, Yañez et al. 2000).

In 2005, LICONSA's programmes benefited more than 5.5 million individuals from low income families below the poverty line (SEDESOL Comunicados 2006). The programme has demonstrated good results in the reduction of childhood anaemia and malnutrition in pregnant women (Instituto Nacional de Salud Pública 2004). However, it has been criticised because it has not served the more than 7 million families that LICONSA did in the late 1980s (Badillo 2003). It supplied milk to just one third of the eligible population in 2002 (approximately 15.6 million children and adults living below the poverty line), to which LICONSA responded that the Secretariat of Finance had restricted its budget to buy NFDM (Aragón Mladosich and Gómez Ibañez 2004). On the other hand, LICONSA has been accused of favouring the large dairy firms (e.g. Lala) to supply NFDM, which has raised doubts about the efficiency of the programme and

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[43] LICONSA has three facilities in the Estado de México (Tlalnepantla, Tláhuac and Valle de Toluca) and other seven in Querétaro, Jalisco, Oaxaca, Veracruz, Tlaxcala, Michoacán and Colima. All are located close to main cities with large urban populations. LICONSA website: http://www.LICONSA.gob.mx (February 28, 2005)

[44] DICONSA is the sister organisation of LICONSA established in 1972. It is the largest network for the distribution of food for social programmes. (i.e. corn, beans, rice, sugar, corn flour, fluid milk and NFDM in multi-foil sachets in rural areas).

[45] The conservation of fresh milk relies on the pasteurisation process carried out the day before the product is distributed overnight to the shops before sale from 6am to 8 am. The shelf life of the product is no more than 3 days.

[46] For this programmes, LICONSA gets the UHT milk from private dairy firms.

suspicions of possible distortions in its execution (Badillo 2003; Sierra Sánchez 2003; Turati 2003; Aragón Mladosich and Gómez Ibañez 2004). However, the benefits to the population do not have a price tag because there is no way to assess these benefits[47].

b) LICONSA and its milk development programmes

In addition to its social programme, LICONSA has participated in several activities: a) the development programmes to increase milk production; b) import substitution of NFDM (Marín López 1997; Marín López 1999; del Valle Rivera 2000); and c) LICONSA 'acted' as a regulator of fresh milk market price (Marín López 1997; Marín López 1999; Gundersen, Yañez et al. 2000; Cervantes Escoto 2003; Aragón Mladosich and Gómez Ibañez 2004).

LICONSA was involved in milk production development activities since the mid 1980s, in the areas of feedstock production, development of milk catchment centres, production of heifers, production and distribution of semen and embryo transplantation for pure breeds and phenotypes FI for dual-purpose farms (García Hernández, Aguilar Valdés et al. 2005). These activities ended in 1997 when LICONSA broke up its assets donating its embryos and semen banks to dairy farmers' associations and its veterinary lab to the state government organisations and universities to support regional education and research programmes. LICONSA donated its chilling infrastructure (i.e. 333 collective chilling tanks) to dairy farmers. The main beneficiaries were small farmers that integrated to chilled milk networks and eliminated 'ruteros' (Sánchez Aldana and Ramírez Castañeda 1999).

To ensure its increased demand of milk, in 1992, LICONSA had 18 milk collection centres, which provided an unstable supply of milk. LICONSA offered dairy farmers a support price for the surplus season when prices decreased by 50%. In addition, the firm

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[47] The costs of the programme cannot be directly weighed against the benefits. Instead, it is appropriate to assume that the social benefits are sufficient to justify the programme as the programme's costs compete with other possible government expenditure. It is nonetheless relevant to ask whether LICONSA's programme is performing efficiently and whether the programme has chosen the best means to fulfil the mission and has implemented these means effectively. Reducing the costs of the programme while delivering the same or greater coverage would clearly improve its social value. This discussion of the importance of LICONSA's programme has been on the political agenda of the MDS. Some supporters of the neo liberal economic process have made efforts to dismantle the programme. However, LICONSA programme's supporters, including politicians, civil servants and social groups, argue for the social benefits of the programme, while generally conceding its high cost.

implemented more rigorous milk quality testing to standardise milk quality. Giving dairy farmers feedback on milk quality, helped them to improve their farming processes (Ramírez Castañeda 1997).

Since 2002, LICONSA has operated a programme for nationally produced milk (i.e. Programa de Adquisición de Leche Nacional, PALN) under pressure from the dairy farmers, and this has had political implications (Gallardo Jiménez 2005; Guerra Márquez 2005a). It increased its milk catchment centres to 38 and created a network of approximately 8,650 small and medium sized dairy farmers (approximately 14.4%[48] of the total national dairy farms estimated in 60,000) (SEDESOL Prensa 2004). This network increased to an estimated 10,000 in 2005 (LICONSA 2005c; SEDESOL Comunicados 2006) and LICONSA increased its national catchments of milk by 367% in the period 1994-2005 (see Table A2).

Table A2 LICONSA milk collection centres and suppliers, 1992-2005

Year	Milk collection Millions of litres per year	Milk collection centres	Number of suppliers and average litres per day
1992	68	18 *(1)*	1,447 (131)
1993	80	18 *(1)*	742 (202)
1994	76	18 *(1)*	429 (360)
1995	63 (Jan-Aug)	18 *(1)*	310 (478)
1996	31.5	NA	73
2002	95.7 *(2)*	NA	NA
2003	183.1 *(2)*	NA	NA
2004	195-200 *(3)*	NA	8,650 *(4)*
2005	278.4 *(5)*	38*(6)*	10,000 *(5)*

Source: Author's elaboration of data from the following sources:
(1) States of Colima, Jalisco, Tlaxcala, San Luis Potosi, Estado de Mexico, Nuevo Leon and Michoacán (Ramírez Castañeda 1997, Sánchez Aldana and Ramírez Castañeda 1999).
(2) LICONSA (2005).
(3) Estimation from Senado de la Republica
http://www.senado.gob.mx/sgsp/gaceta/?sesion=2005/04/05/1&documento=50
(4) SEDESOL Prensa 2004
(5) SEDESOL Comunicado 2006
(6) States of Campeche, Colima, Jalisco, Tlaxcala, Estado de Mexico, Guanajuato, Chihuahua, Veracruz, Oaxaca, Michoacán, Querétaro, and Zacatecas (LICONSA 2005b).

By 2005, individual and associated dairy farmers in cooperatives and rural production societies supplied approximately 32% of milk volume[49], in 17 States for 35 states social

[48] Author's estimation of data of SEDESOL Prensa (2004) of approximately 60,000 dairy cattlemen in the country in 2004.
[49] Author's estimation based on LICONSA distributing approximately 3.3 million litres per day by 2005 equivalent to 861.3 million per year (261 days), and 278.4 million litres of this was fresh milk (32% of its total distribution by 2005) (LICONSA 2005a; SEDESOL Comunicados 2006).

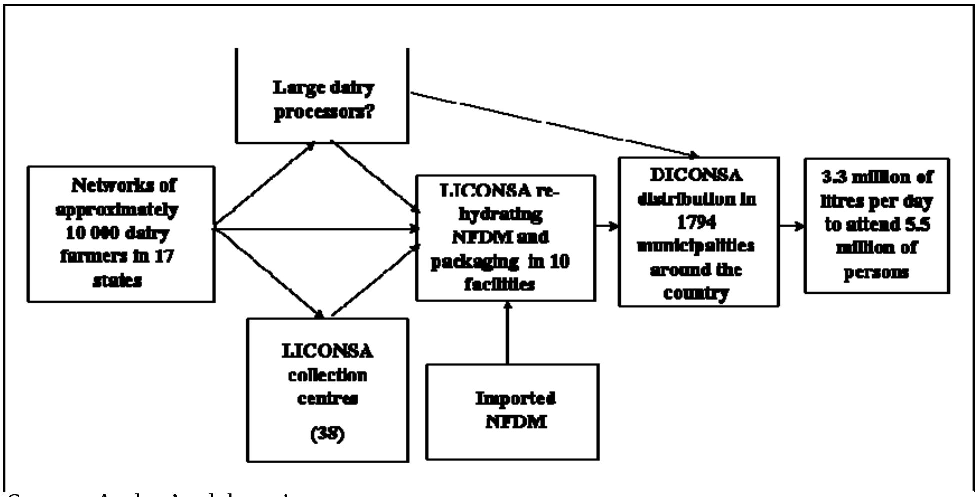
programmes. Dairy farmers from Jalisco and Chihuahua were the main suppliers (approximately 77% of the total) (see Table A3).

Table A3 LICONSA milk collection by 2004

State	Litres of milk *(1)*	%
Aguascalientes	581,942	0.39
Baja California	1,181,255	0.79
Chihuahua	39,777,213	26.53*(2)*
Colima	485,305	0.32
Chiapas	2,008,052	1.34
Coahuila-Durango	372,712	0.25
Guanajuato	407,511	0.27
Hidalgo	1,304,3464	8.70
Jalisco	76,517,119	51.03*(2)*
Michoacán	588,777	0.39
Querétaro	1,019,163	0.68
Tabasco	11,704,133	7.81
Tlaxcala	68,863	0.05
Estado de Mexico	39,100	0.03
Veracruz	2,152,451	1. 4
Total	149,947,060	100.00

(1) Supplied by approximately 8,650 cattlemen (SEDESOL Prensa 2004).
(2) By 2005, the participation of Chihuahua increased to 31% and Jalisco decreased
to 49% of the total of 278.4millions of litres supplied by approximately 10000 dairy farmers of 17 states of Mexico (SEDESOL Comunicados 2006).
Source: Author's elaboration of data from LICONSA (2005).

The value chain of LICONSA could be portrayed as follows.



Source: Author's elaboration.

Figure A4 LICONSA value chain by 2005

LICONSA favoured the big dairy farmers in some regions for the collection of milk as well as big dairy firms, which supply processed milk to its programmes (Sánchez Aldana and Ramírez Castañeda 1999; Badillo 2003; Sierra Sánchez 2003; Turati 2003; LICONSA 2005a). The large firms have doubly benefited from LICONSA, by supplying milk to it, which saves on the associated tax tariffs and allowing the purchase of NFDM beyond the agreements, which benefits from the subsidised international price (Cervantes Escoto 2003; Sierra Sánchez 2003; Turati 2003).

Regarding regulation of fresh milk prices, dairy processors argue that since the PALN, LICONSA has been acting unfairly because it has paid higher prices for fresh milk than those set by the dairy firms (i.e. Nestlé, Lala, Alpura, Lechera Guadalajara, Sigma Alimentos) (Cevallos Urueta 2005). This has had two effects: on the one hand, it has obliged dairy firms to increase the price paid to dairy farmers to compete with LICONSA benefiting dairy farmers (Gallardo Jiménez 2005; Guerra Márquez 2005a). On the other hand, it has not helped the dairy farmers to improve their farming practices, because LICONSA's suppliers do not have any incentives to improve milk quality.

Regarding its industrial activities, LICONSA has proved efficient at producing pasteurised milk from NFDM and distributing it without chilling. The firm has upgraded and modernised its managerial and financial capabilities to achieve breakeven in operation (Aragón Mladosich and Gómez Ibañez 2004; LICONSA 2005a). It has succeeded in developing new enriched dairy formulas to satisfy the demand of its target population (Aragón Mladosich and Gómez Ibañez 2004; LICONSA 2005a; SEDESOL Comunicados 2006). However, it has no high quality network of milk suppliers similar to the large dairy firms, although the quality of the milk collected has increased[50] (see Table A4) (LICONSA 2004; Guerra Márquez 2005b) (see Los Altos case). Second, the import substitution programme has a very low impact on the MDS (approximately 7.89% of milk imports).[51] Third, as a regulator of the price of fresh milk, LICONSA 'is perceived' as an unfair competitor despite its low participation in the catchments of

[50] Whereas large firms are demanding chilled milk Reductase tested for between 9 to 10 hours; LICONSA's standard is minimum 2 hours (Guerra Márquez 2005b).
[51] Author's estimations based on approximately 200 million litres of fresh milk collected in 2004, which represents approximately 7.89% of the total of equivalent of milk imports (2,532 million litres) by 2004 (see Table 2.11 in Chapter 2).

fresh milk, approximately 2.02% of the total of milk production,[52]. Moreover, its association with big farmers and firms has raised doubts about its achievements (Aragón Mladosich and Gómez Ibañez 2004).

Table A4 LICONSA raw fresh milk quality classes by 2004

Milk classes	Methylen blue test or reductase test	Content of cells Millions of cells per ml
I Good quality	> 5.5 h	0.5
II Medium quality	2.0 - 5.5 h	0.5-4.0
III Bad quality	15 min – 2.0 h	4-20
IV Very bad quality	< 15 min	> 20

Source: LICONSA (2004).

The combination of access to imported milk, a reasonable efficient manufacturing and distribution system and some sales of NFDM allowed LICONSA to operate the social milk programme without any budget support until 2003 (Aragón Mladosich and Gómez Ibañez 2004).

LICONSA seems to be implementing a strategy to pursue an aim that MNCs and larger domestic firms achieved with a similar price strategy. Nevertheless, its complementary activities to achieve its aims, particularly in raising milk quality in the MDS, do not appear to be as effective. Furthermore, its strategy to regulate the milk market seems unorthodox and unclear.

In summary, LICONSA has had some industrial achievements (see Table A5) and has contributed to developing some capabilities in the MDS such as: a) integrating networks of suppliers of fresh milk; b) improving its control and operation processes; and c) developing enriched dairy formulas accordingly to the demand of its target population.

[52] Author's estimations based on approximately 200 million litres of fresh milk collected in 2004, which represents approximately 2.02% of total of milk production (9,874 million litres) by 2004 (see Table 2.11 in Chapter 2).

Table A5 LICONSA industrial and social achievements by 2005

Milk social assistance programme benefiting more than 5.5 millions of individuals under the line of poverty in 2005
Increasing collection of national milk benefiting approximately 8 650 cattlemen, in 2004, and 10 000 by 2005. Increasing to 367% in the collection of national milk in the period of 1994-2005
Acquisition of national milk and powdered milk from producers of Chihuahua and Baja California, substitution of imports of powdered milk estimated in 23% of total produced and distributed in 2005
Network for distribution in 179A municipalities around the country
ISO 9001:2000 certification for the elaboration and packaging of pasteurised milk in the facilities of Tlalnepantla, Valle de Toluca and Tláhuac (Estado de México), Oaxaca, Querétaro and Tlaxcala
ISO 9001:2000 certification for distribution process, facility of Tlaxcala
Clean Industry Certification by PROFEPA in the facility of Tlanepantla (Estado de Mexico) for reduction in the use of water, energy and waste of raw materials
Development of dairy formulas: 'Te Nutre' supplemented dairy formula, 'Nutrisano' children dairy formula and 'Nutrivida' pregnant women dairy formula associated with the Instituto Nacional de Ciencias Médicas y Nutrición, Salvador Zubirán and assessed by Instituto Nacional de Perinatología to decrease malnutrition, and anaemia.
Association with pasteurising private firms to pasteurising, packing and distributing milk in Colima, Coahuila, Durango, Jalisco, Michoacán, Oaxaca and Tlaxcala
Elaboration of 132 manuals for the planning and control process of distribution of powdered milk for the social assistance programme of milk
Certificated by QS México A.C. A certification for social organisations which promotes the non-discrimination, Gender Equity Certification
Investment in lab equipment and training of personnel to modernise the collection centres and processing facilities
Development technical manual for raw fresh milk (i.e. Manual técnico de control de leche cruda LICONSA, S.A. de C.V. Dirección de Producción)
Winner of the Intragob 2003 prize (www.intragob.org.mx) by the Secretariat of Economy to government organisations which promote the culture of total quality, productivity, technological innovation and social responsibility
Distinction for the development of a culture of a social responsibility involvement promoted by SEDESOL for the achievement of benefiting more than 5.5 million of individuals in 2005, ESR 2003-2004 (Empresa Socialmente Responsable)

Source: Author's elaboration of information from LICONSA (2005).

2. Dual role of MNCs in the Mexican dairy sector

MNCs have been important drivers of innovation in the MDS, first, by integrating the value chain in the tropical and temperate regions, i.e. the role of Nestlé, second, by supplying inputs for agriculture, milk production and dairy processing, which has influenced the upgrading of milk and dairy technologies.

2.1 MNCs as drivers of the integration of the value chain in the tropical and temperate regions, the case of Nestlé

Nestlé has increasingly integrated mainly dairy farmers since it was established in Jalisco[53] in 1935 and later on in other tropical regions following three strategies.

a) The development of networks of small milk suppliers

Nestlé stated the collection of non-chilled milk from small dairy farmers and 'ruteros'. Some had chilling tanks in their farms and chilled transport. Since the quality of milk was heterogeneous and cross contamination was common, in the late1980s, the firm introduced collective chilling tanks located close to farms. There, farmers' milk was individual tested before being accepted for chilling and transport to Nestlé facilities. During the 1990s, Nestlé forced the farmers to set up individual tanks, a move criticised by several academics, who argue that the farmers carried out with the financial cost (del Valle Rivera 2000; Rodríguez Gómez 2000; Cervantes Escoto 2003). Since 2000, Nestlé has collected 100% of the chilled milk in all the regions[54] that supply milk to its facilities in Chiapas, Jalisco and Veracruz (Enrigue Loera 2005; Godínez Vázquez 2005). The introduction of individual chilling tanks (cf. collective chilling tanks) has proved to be the most effective way to sustain the quality of milk, and avoids cross contamination (Cervantes Escoto, Santoyo Cortés et al. 2001; Muñoz Rodríguez, García Muñiz et al. 2003).

Nestlé's strategy focused mostly on integrating small dairy farmers (cf. Lala and Alpura). In the Mexican high plateau (i.e. Jalisco, Queretaro, Guanajuato and Coahuila), Nestlé collects milk from around 1,200 dairy farmers with an average production of 400

[53] Nestlé started operations in Mexico as an importer of food products in 1930. In the dairy sector, it started in Ocotlán in the state of Jalisco with a facility to produce sweetened condensed milk in 1935. In 1944, a second facility to produce powdered milk and infant formulas was set up in Lagos de Moreno, Los Altos region in Jalisco. Nestlé started to produce dairy products in 1961, its access to the cheese market improved with the acquisition of a cheese making facility (i.e. Quesería Club) in Tlaxcala**.** In 1963, Nestlé started up a new facility for dairy products in Tamuín, in San Luis Potosí state. Two years later, in 1965, the firm acquired the facility and brand, Bambino, to produce frozen food and ice cream. In 1970, in Chapa de Corzo in the state of Chiapas, a new facility to produce powdered milk was built. In 1973, Nestlé started the production of yoghurt. In 1985 it took over Carnation (an American firm producing evaporated milk) and its two facilities in the states of Querétaro and Durango. In 1988 it took over an ice cream producer, Helados Danesa 33 and in 1991 built a second facility to produce ice cream in Lagos de Moreno, in Jalisco State. The firm has followed a business diversification process including mergers and acquisition in a full range of other food processed products (i.e. bottled water, packed fruit juices, production of snacks based in cocoa, breakfast cereals, dressing and sauces) and in 2002, acquired Purina PetCare for pet food.
From Nestlé website: http://www.Nestlé.com.mx/bAcercaNestlé/templateInterior01.asp?Id=1 (May 30, 2005).
[54] The success of Nestlé in Mexico is attributed to: a) good business practices to support farmers, and b) good political connections in the mid 1990s which got it the support of the Mexican government to set up chilled tanks (Dobson 2001).

litres of milk per day. In the tropical area (i.e. Veracruz, Chiapas, Tabasco, Campeche and Oaxaca) it has around 950 suppliers who produce on average 100-120 litres per day with herds of between 15 and 20 cows (Enrigue Loera 2005).

b) The introduction of a technological package for milk production

According to Godínez Vázquez (2005), in addition to the chilling networks development, Nestlé has successfully introduced its technological package through its dairy cattle development programme (i.e. Programas Integrales de Manejo de Ganado)[55] based on the Holstein model to help dairy farmers to improve the quality of milk, to increase the productivity of milk production systems and to improve the profitability of the production units.[56] The mechanisms of this programme can be summarised as follows: a) technical assistance, which includes conferences and training programmes with MNCs for inputs to milk production (e.g. chilling tanks, milking systems, seeds for intensive grazing, frozen semen, etc.). Nestlé's veterinarians and agronomists (approximately 44 in the tropical region) also assist dairy farmers to improve their farming practices; b) financial support (i.e. lower than market interest rates) to dairy farmers to buy from Nestlé the inputs and these credits are repaid through deductions made in dairy farmers' payments. Currently, Nestlé's milk prices to dairy farmers take account of the solids and bacteriological content, and fat and protein content, the latter being a better measure of milk quality associated with good farming practice; and c) supply of feedstock and assistance with lab tests for improved animal nutrition.

It has been argued that the 'imposition' of Nestlé's technological package[57] has helped to improve grazing and herd management and eventually the profitability of small farmers (Aranda Ibáñez 2005; Enrigue Loera 2005; Godínez Vázquez 2005; Moreno Ramírez 2005). However, expectations that the firm is investing in milk production

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[55] Nestlé web site: http://www.Nestlé.com.mx/site/acerca_Nestlé/apoyo_campo.asp. (March 30, 2005).

[56] The results show that milk production cost in the tropical regions in Mexico is competitive with other regions in Latin America (Godínez Vázquez 2005).

[57] Nestlé has been criticised by academics because of the way it ousted many dairy farmers from economic activities. The firm imposed its production model and milk purchasing prices in areas where there were no other options for milk collection (i.e. mainly in the tropical regions) (Alvarez Macías 2005; Cervantes Escoto 2005; Chombo Morales 2005; del Valle Rivera 2005; Rodriguez Gómez 2005). Nestlé argues that it aimed at concentration in milk production activities to achieve economies of scale and that productivity per cow increased (Enrigue Loera 2005). E.g., La Fraylesca region in Chiapas state achieved increased milk production and a new dairy facility was set up in early 2005 (Arista Puigferrat 2005; Arrieta González 2005).

development are low because, since 2008, Nestlé can import NFDM without any restrictions (Cervantes Escoto 2005; del Valle Rivera 2005; Rodríguez Gómez 2005).

Similar strategies to Nestlé's have been developed by other large and medium sized domestic dairy firms to develop their networks of milk suppliers.

c) The development of the genetics of the herd for tropical region

Nestlé with INIFAP La Posta in Veracruz developed a research project in the late 1980s, to address the development of the genetic crossbreeding (i.e. animals resistant to high temperature and humidity and parasitic). The main achievement of this project was the development of F1 phenotype semen 3/5 and 5/8 of European-Zebu, which has reached a certain heterosis[58] (Dávalo Flores 1997; Castañeda Martínez 2005; Enrigue Loera 2005; Valdovinos Terán 2005). By 2005, although some production of semen was still being carried out in INIFAP La Posta in Veracruz and INIFAP Las Margaritas in Puebla, it was not on an industrial scale (Castañeda Martínez 2005; Valdovinos Terán 2005).

2.2 MNCs as suppliers of inputs for agriculture, milk production and dairy processing

MNCs have led innovation in milk production (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000), because dairy sector is supplier-dominated (Pavitt 1984).

a) Agriculture and milk production

The MDS depends heavily on imports of inputs for agriculture and milk production. This dependence has increased since NAFTA because of the improvement in the access to those goods (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000). This includes increased imports of grains for animal feedstock, since the productivity of those commodities in Mexico is low compared to US production[59] (Hernández Laos and

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[58] Heterosis or hybrid vigour is the increase in characteristics such as size, growth rate, fertility, and yield of the hybrid animal, over those of its parents. (http://www.britannica.com/search?query=heterosis (February 15, 2007).

[59] It has been argued that the agriculture production in the US (and EU) is highly subsidised and this helps producers compete in international markets. It is difficult to predict what would happen if subsidies programme be removed. One possibility is simply greater volatility in agricultural prices, which could be even more problematic than the current system. Another is that, with more medium sized farmers out of the market, there would be further mass production consolidation and price reduction or that they would produce even more in order to sustain income. It could be that the US and Europe should eliminate tariff and quota barriers to all agricultural imports and sort out income support for farmers in a different way

del Valle Rivera 2000; Austin, Chu et al. 2004; Alvarez Macías 2005; del Valle Rivera 2005).

The international suppliers have well developed and long established networks of distributors, especially in regions with irrigation systems (e.g. north and central parts of the country). They have been working with farmers, FIRA, SAGARPA and INIFAP to incorporate more technology to mechanise agriculture and milking as well as to build up networks of chilling systems (del Valle Rivera 2000; Hernández Laos and del Valle Rivera 2000). These networks have expanded to tropical regions, i.e. 'Ganaderos'[60] in the southeast of Mexico (Caraveo Márquez 2005; Lamas de los Reyes 2005).

The inclusion of milking and chilling systems has been rapid in the centre and south of the country (Callieri 2005; Reinert Fernández 2005) because of the training and professional assistance from suppliers to help dairy farmers (Caraveo Márquez 2005; Madero Gámez 2005; Reinert Fernández 2005), e.g. PROLECHE[61] (Callieri 2005), and some associated services for maintenance of milking systems developed by the main distributors, e.g. DeLaval and WestfaliaSurge. However, there are still problems with the expansion and standardisation of these services in the tropical regions (Caraveo Márquez 2005; Reinert Fernández 2005). As result, very few endogenous capabilities have been created for the design and production of milking and chilling systems because of the lack of support of government to small entrepreneurs[62] (Lamas de los Reyes 2005) to develop this type of complementary technologies and capabilities. It has been argued that the size of the Mexican market for the supply of capital goods for milking is not enough to justify producing those goods in Mexico (Reinert Fernández 2005).

(such as paying them to be 'stewards of the land'). Therefore, the removal of subsidies in foreign countries might not produce improvements in agricultural production in Mexico if other areas of the Mexican agriculture organisation of production do not improve in the short term (Steinmueller 2007 discussion).

[60] 'Ganaderos' is a network of cattle suppliers in the tropical region. It is part of UGR Tabasco (see Tabasco case, Chapter 5, section 5.3).

[61] PROLECHE is a group of MNCs (i.e. Boehringer Ingelheim Vetmedica, SA de CV and DeLaval, SA), which has collaborated with farmers to improve the quality of milk and to increase productivity on farms. PROLECHE holds commercial exhibitions and technical training programmes with Lechera Guadalajara, COFOCALEC, FIRA, Universidad de Guadalajara, etc. in Lagos de Moreno and in other dairy regions. This concept of collaborative work was successfully developed and implemented in Argentina in 1995; and is implemented in Mexico since 2001 (Callieri 2005).

[62] ORDEMEX is a producer of milking system for small herds, which has developed its own systems based on its own design. The firm receives no support from government or any other public financial organisation to grow its market (Lamas de los Reyes 2005).

b) Dairy processing

In the case of industrial milk and dairy processing, MNCs have played a core role in upgrading technologies. Large and medium sized firms have had access to international suppliers of technologies either acquiring technologies or through alliances, e.g. Lala, Alpura and Sigma Alimentos (Arista Puigferrat 2005; Arrieta González 2005; Báez Durán 2005; Hernández Astorga 2005; Ortíz 2005; Otaduy 2005; Quintanilla Alvarez 2006). The small dairy firms and artisan producers rely on the assistance of MNCs professionals, Mexican dairy specialists (Alonso Capetillo 2005; López López 2005), their own experience (Anaya Zermeño 2005; Guardado González 2005; Valdivia Valentín 2005) and some public research centres, e.g. CIATEJ (Chombo Morales 2005; de la Peña Marshall 2005).

3. Other organizations influencing the development of the Mexican dairy sector

As mentioned earlier, the MDS involves many actors whose participation is not always very clear. These actors have had effects, both positive and negative, on the development of the system and further increased the complexity of the interaction of the actors in the system.

3.1 Livestock producers' associations and their political influence to the MDS

The livestock producers' associations socially and politically influence the MDS. This is the case of the Confederación Nacional de Organizaciones Ganaderas, CNOG, which represents more than 2,050 state and local livestock producers' associations.[63]

The origins of CNOG go to pre-revolution times.[64] However, it was not until 1932 that the Mexican government established the law for livestock producers' associations, which aimed to define the strategies for livestock development, and in 1936, the

[63] These associations include all types of livestock producers e.g. the largest national dairy farmers associations, i.e. Asociación Nacional de Ganaderos Lecheros A.C. ANGLAC. Nevertheless, dairy farmers constitute a small group of producers compared with the beef cattle producers, which dominant the representation of the CNOG.

[64] The King of Spain required the vice royal of 'La Nueva España' (the former name of Mexican territory before turned into republic in 1824 after the independence from Spain) to register and control animal heads livestock production units (i.e. 'Ranchos' and 'Haciendas' for production of poultry, hogs, sheep and cattle) in order to facilitate the collection of taxes. CNOG web site: http://www.cnog.com.mx/CNOG/antecedentes.html (September 30, 2007).

National Confederation of Livestock Producers (Confederación Nacional Ganadera, CNG, currently CNOG) was set up. Since then, its main activities have been to lobby government to get resources and political support for regional development in the areas of a) animal health campaigns, b) national and international trade regulations for livestock products (e.g. the identification of unfair trade practices in the international trade), c) economic analysis of livestock production to improve decision making, d) assistance to introduce information technologies on farms, and e) the development of magazines to publish economic issues related with the livestock production and technologies upgrading (Piedra Ibarra and Ramos 2005).

The CNOG and some of the regional and local cattlemen's associations have been working with private and government organisations supporting successful projects such as:

a) to improve animal health in the tropical regions (Castillo García 2005; Díaz Oliveros 2005; Martín Ruíz 2005);
b) to improve the commercialisation of dairy products in tropical areas (Díaz Oliveros 2005; Gudiño Escandón 2005; Muñoz Pérez 2005; Ramos Flores 2005);
c) to organise the supply of inputs for milk production in the temperate regions, the case of the UGR Jalisco (Arellano Leaño 2005; Valencia Zarazúa 2005) and tropical regions, the case of 'Ganaderos' (Caraveo Márquez 2005);
d) to organise milk farmers for the industrialisation of milk, the case of JAMALAC in Veracruz (Alonso Capetillo 2005; Valdivia Valentín 2005);
e) to organise milk producers for technology transfer using DEPAI and GGAVATT groups to improve milk production in Veracruz (Castellanos Rábago 2005; del Angel Juárez, Molina del Angel et al. 2005; González Díaz 2005; Lagunes Ortega 2005; Muñoz Pérez 2005) and Jalisco (Arellano Leaño 2005; Pérez Pérez 2005; Santoyo Pérez 2005; Valencia Zarazúa 2005);
f) to create demonstration and teaching centres to improve milk and cattle production in Veracruz, the case of the Unión Ganadera Regional Sur de Veracruz (i.e. UGRSV) (Velasco Casarrubias 2005) and Unión Ganadera Regional Norte de Veracruz (i.e. UGRNV) (Muñoz Pérez 2005);
g) to collaborate with SAGARPA in the national committees for the planning processes to increase the productivity and competitiveness of the dairy livestock production system (i.e. CSPBL).

These livestock producers' associations have been criticised because they represent mainly the vested interest of the most influential large producers dominated by beef producers (e.g. Jalisco, Veracruz, Tabasco) and milk producers (e.g. La Laguna); and have failed to influence government to develop policies to improve technologies and infrastructure of numerous small farmers mainly in tropical dairy regions, who have neither the economic power to influence the system nor the political representation to demand protection when they are affected by national trade policies and international support prices for milk and grains for livestock production in the US and Europe (Romero Tellechea 2005). They have also, in many cases, served the politicians in power, i.e. PRI politicians, from whom some members of those associations have benefited.[65]

Other civil associations that have played an increasing role in the development of dairy farming are Holstein de México[66] established in 1959. Since then it has the inventory of specialised dairy cattle (approximately 95% of the specialised milk cows on private farms, which constitute between 10 to15% of the national milk herd), and associations of cow breeders such as Holando Cebú (i.e. crossbreeds cows) in tropical regions (Gurza Merino 2005; Ruíz López 2005). However, the database is not being used because of the lack of interactions among farmers and other government organisations to improve the planning process of dairy production, which is still based on mathematical models (Cevallos Urueta 2005; Gómez León, Alvarado de los Santos et al. 2005; Ruíz López 2005).

3.2 Professional and industrial organisations influencing the MDS

Professional and industrial organisations are two groups that participate in developing capabilities in bovine health and reproduction, but are not involved in dairy processing.

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[65] Information from several interviewees, who asked not to be identified.

[66] Registration of the dairy herd started at the end of the 19th century in the US and Europe. A large percentage of the herd registered and monitored for health control and productivity variables (i.e. genetics, animal health, nutrition, insemination, milking, dry periods, milk productivity, conversion of feedstock, etc.). This registration provides the technical bases for breeding and milk production planning (Ruíz López 2005).

a) Professional organisations

The main organisations of professionals specialised in bovine health and reproduction (i.e. Federación de Colegios y Asociaciones de MVZ de México, AC; and Asociación Mexicana de Médicos Veterinarios Especialistas en Bovinos, AC, AMMVEB, Academia Veterinaria Mexicana, AC) have been working with the universities and veterinary faculties, to educate agronomists and veterinarians to provide services to the dairy farmers. Their members are located mainly in Mexico City within the veterinary faculty (e.g. Facultad de Medicina Veterinaria y Zootecnia of the UNAM). They have been working with other state organisations, e.g. the Colegio Estatal de Médicos Veterinarios Zootecnistas in Veracruz and the AMMVEB to train the professionals in bovines reproduction, health and commercialisation, and GGAVATT method (Alpírez Mendoza 2005; Ruíz Arriaga 2005; Valdovinos Terán 2005).

b) Industrial dairy associations

There are no specific dairy processing professional associations. Most dairy professionals are associated with food science and biotechnology professional associations.

In the case of the dairy processors, there is a national industrial dairy association (i.e. Cámara Nacional de Industriales de la Leche, CANILEC), which has membership of dairy producers and dairy suppliers (approximately 130 members in 2005). CANILEC claims that it has contributed to the improvement of dairy processing productivity and competitiveness by ensuring the supply of inputs for dairy processing (e.g. NFDM, milk preparations, food additives, etc.), supporting the commercialisation of national and imported dairy products, and participating in the CSPBL committee (García González 2005). However, there is no evidence of its participation in technological dairy development.

4. Summary

This Appendix explains the complex political structure and context (a multiplicity of public and private actors and their institutions) have influenced dairy farmers and firms to respond to NAFTA.

It is clear that the neo liberal trade policy in Mexico has led to structural reforms in the agriculture sectors, which have affected the dairy farmers and firms and created new institutions in the MDS in several ways, which are summarised in Table 2.1 in Chapter 2.

SAGARPA created and implemented a top-down policy, i.e. PROCAMPO/Alianza para el Campo, as part of the government's strategy to mitigate the effects of NAFTA on the dairy farmers, which were technologically disadvantaged compared to the US and other international supplier of milk and dairy products. Alianza para el Campo with limited resources has influenced to some extent the development of the infrastructure and capabilities for regional dairy milk production systems (i.e. milking and chilling systems), supplemented by other financial organisation (i.e. FIRA, Financiera Rural and FIRCO).

Following neo liberal economic trends, the land tenure regime changed in 1992 giving flexibility to the owners of the land, and a new central planning process for the MDS was created, i.e. the CSPBL, which has not significantly influenced the coordination of the activities in the system. Some of the actors in the SNIA, e.g. INIFAP, changed and new organisations (e.g. Fundaciones Produce) and mechanisms for technology development and transfer processes were created and have achieved some success (i.e. DEPAI and GGAVATT method in tropical regions and PIAL in La Laguna).

LICONSA's programme has created a demand for fresh milk that has influenced the integration of the value chain differently in the regions, through unorthodox strategies. CNOG and regional cattle organisations have influenced the political environment of the dairy farmers specifically in relation to animal health campaigns and limited achievements in integration of the value chain.

MNCs have increasingly supported innovation in integrating the value chain (the case of Nestlé) and modernising the MDS (i.e. a supply-dominated sector). But these changes have been uneven across regions.

The spectrums of policies and activities that support the actors in the MDS have attempted to address competitiveness and productivity but have failed at the systemic level. They have favoured the large producers in specialised milk production systems (e.g. the allocation of resources of Alianza para el Campo, FIRA and the application of resources for research via Fundaciones Produce) as well as dairy processors.

The MDS may be able to achieve improvements without government intervention but it will be more difficult and risky for the regions. It could be that some of them will be locked out of the new technological paths without opportunities to upgrade their technologies and expand their markets (e.g. tropical regions), whereas others (arid and semi arid regions) might be able to reach scales of production but create regional problems which might put the long-term sustainability of the MDS at risk.

This thesis argues that a principal reason for this is not the absence of actors, but the lack of efficient coordinating mechanism for the top-down implementation processes of the policies in the regions because of the very different regional features of the MDS. In order to formulate a more effective policy, knowledge that is region specific is needed and specific policies need to be formulated to be more effective aiming at the long-term sustainability of the system.

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