Catching up or Being Dependent:

The Growth of Capabilities among Indigenous Technological Integrators during Chinese Development

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DECLARATION

I HEREBY DECLARE THAT THIS THESIS HAS NOT BEEN SUBMITTED, EITHER IN THE SAME OR DIFFERENT FORM, TO THIS OR ANY OTHER UNIVERSITY FOR A DEGREE.

SIGNATURE: KAIDONG FENG

Contents

List of Figures

List of Tables

Abbreviation

2G: The second generation (of mobile systems)

3G: The third generation (of mobile systems)

ABS: Antilock Braking System

ASIC: Application Specific Integrated Circuit

AVIC: China Aviation Industry Corporation

BS: Base Station

BTM: Bell Telephone Manufacturing Co.

CAD: Computer-Aided Design

CAE: Computer-Aided Engineering

CATT: China Academy of Telecommunication Technology

CCP: Chinese Communist Party

CIT: Centre of Information Technology at Zhengzhou Institute of Information Engineering of the People's Liberation Army

CKD: Completely Knocked Down

CNAJC: China National Automobile Joint Company

COCOM: Coordinating Committee for Export to Communist Countries

CuAE: Customer Application Engineering

DC: Developing Country

DTT: Datang Telecom Technology Corporation, Limited

DVD: Digital Video Disc

EPS: Electronic Power Steering

FAW: First Automobile Works Group Corporation

FDI: Foreign Direct Investment

FFE: Foreign Funded Enterprise

FYP: Five-Year economic Plan

GDP: Gross Domestic Product

GDT: Great Dragon Telecom Technology Corporation, Limited

GNP: Gross National Product

IC: Integrated Circuit

IPR: Intellectual Property Right

JV: Joint Venture

KD: Knocked Down, including CKD pattern and SKD pattern

LSI: Large Scale Integration

LTEP: Luoyang Telephone Equipment Plant

LTE: Long Term Evolution

MBO: Management Buy Out

MEI: Ministry of Electronics Industry

MII: Ministry of Information Industry

MMI: Ministry of Machinery Industry

MNC: Multinational Corporation

MOAI: Ministry of Aviation Industry

MOE: Ministry Owned Enterprise

MPT: Ministry of Posts and Telecommunications

MPV: Multi-Purpose Vehicle

NICs: Newly Industrialising Countries

NVH: Noise, Vibration and Hardness

OBM: Own Brand Manufacturer

ODM: Own Design Manufacturer

OEM: Original Equipment Manufacturer

PATAC: Pan Asia Technical Automotive Centre Co., Ltd

PBX: Private Branch eXchange

PCT: Patent Cooperation Treaty

PDSS: Public Digital Switching Systems

PTIC: China Posts and Telecom Industrial Corporation

R&D: Research and Development

RASM: Remote Autonomous Switching Module

RBV: Resource Based View

RMB: RenMinBi, the Chinese Currency

S&T: Science and Technology

SAIC: Shanghai Automobile Industry Corporation

SASAC: State Assets Supervisory and Administration Commission

SCDMA: Synchronous Code Division Multiple Access

SECI: Socialization – Externalization – Combination - Internalization

Shanghai-Bell: Shanghai-Belgium BTM, Alcatel-Shanghai-Bell, or Alcatel-Lucent-Shanghai- Bell at different periods of time

SKD: Semi-Knocked Down

SMEC: Shanghai-Mitsubishi Elevator

SOE: State Owned Enterprise

SOP: Start of Production

SPC: State Planning Commission

SPTE: Shaanxi province Post and Telecom Equipment plant

TDIA: TD-SCDMA Industry Alliance

TD-SCDMA: Time Division-Synchronous Code Division Multiple Access

TMFT: Trading Market for Technology

USSR: Union of Soviet Socialist Republics

WIPO: World Intellectual Property Organisation

WRI: Wuhan Research Institute of Post and Telecoms, also the FiberHome Tech. Group

WTO: World Trade Organisation

Note: the list here only counts the abbreviations that appear at least twice in the main text of the thesis. For those appearing just once or only in tables, figures or appendixes, abbreviations and annotations are made in their contexts.

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SUMMARY

The thesis appraises certain key processes – albeit rather limited in number and scope – widely assumed to be associated with assessing the role of technological capability building in developing country (DC) firms. The latter are affected by their DC status on both the demand side (e.g. by rapid growth of the economy via consumption and trade) and the supply side (of technological catch-up etc.). Such broad considerations set the scene for our specific study. In this thesis, the component of technological capabilities that we highlight by studying local integrated product providers is the capability for systemic product development.

We argue that the organisational system of industrial firms in DCs plays a fundamental role in their technological learning performance. Here, the developmental context is stressed because we suggest that the knowledge about how to organise effective learning, termed "social technology", is at least as scarce as the "physical technology" in such contexts, compared with those prevailing in the developed countries. Therefore, when DC firms shift into a new domain, the organisational systems that they rely on often have to be created rather than simply selected. This may be because, as first-movers in their circumstances, even when they are informed by external sources, they have very little practical experience of carrying out similar actions successfully within their own contexts. Therefore, studying organisational building in their early phase could prove critical for understanding their capability building processes.

Empirical studies of China's car-making and telecom-equipment sectors over the past three decades are taken to support theoretical exploration in this thesis. Some scholars (e.g. Bell and Pavitt, 1992) point out that, in DCs, the growth of production capacity does not automatically lead to the building of technological capability. The experiences of China's car-making and telecom-equipment sectors are exactly in line with this point of view.

From the mid 1980s, the Chinese government implemented a "trading market for technology (TMFT)" policy, encouraging its backbone SOEs (State Owned Enterprises) to establish productive joint ventures (JVs) with MNCs (Multinational Corporations). By doing so, policy-makers expected backbone SOEs to undergo a bottom-up capability building trajectory *via* learning closely from their JV partners. We term these SOEs and their JVs the "Group-A firms" in our research. Contrary to the expectations of policy-makers, Group-A firms were locked into the

manufacturing segment even after twenty years of TMFT practices, and seldom had new systemic products developed indigenously, prior to 2005 at least.

On the contrary, the indigenous advance of technological capability building has actually been led by some new entrants. Their development has been independent of the advocacy of TMFT. They relied on in-house developed products from the very beginning after entering the corresponding industries, and succeeded in building sustainable competitiveness. We term them the "Group-B firms".

By comparing these Group-A and Group-B firms, we argue that there are distinctive differences in organisational learning systems between them. Four components are developed of the concept of organisational learning systems, i.e. the strategic intent, the authority over strategic resource allocation, the pattern of organisational mobilisation and learning integration, and the facilities and institutions for knowledge accumulation. For the latter three components, we succeed in generating a clear contrast between these two groups of firms. We undertake a thorough comparison of authority over strategic resource allocation by studying the constitution of their top committees. As for the patterns of learning mobilisation and organisational integration, we find distinct differences in the scope of knowledge communication of front-line engineers, and relevant institutional arrangements to mobilise, integrate and direct the content of communication. Regarding the facilities for knowledge accumulation and application, the study of their knowledge database building engenders a clear contrast, as well as the institutional arrangements to regulate and promote relevant activities within their organisations.

We also discover significant connections between the organisational systems of Group-B firms and their processes of knowledge search, generation and accumulation. Three important mechanisms of new knowledge creation in Group-B firms are examined, namely learning through recruitment, learning through cooperative projects and learning through interaction with customers. Our empirical study reveals that the authority stressing the investment in new product and technology development, the cross-boundary inter-departmental platform of knowledge conversion, the comprehensive knowledge-accumulating facilities, and the institutions backing these components play fundamental roles in shaping these learning mechanisms.

Therefore, the organisational differences of these two groups of firms are connected with the differences of these two subsets of firms' technological learning performances. Besides, we discuss the social roots of their organisational systems by historically revisiting China's industrial system.

By doing so, for the research community that focuses on technological learning in DCs, this thesis advocates a shift of research from stressing assimilative processes of firms to giving more emphasis to organisational changes as a centrepiece of studies.

Chapter 1. Introduction

1.1 Aim of this research

The central topic of this thesis is the impact of the organisational and institutional dimensions of firms in developing countries (DCs) upon their technological learning with the aim of technological catching-up, with special reference to China. Based on the substantive literature associated with this field, the discussion centres on how firms establish their learning systems and correspondingly mobilise and integrate knowledge search, along with knowledge generation and accumulation. In other words, the focus is on how organisations are built to enable effective learning rather than being on the implementation of learning.

By comparison with the conventional literature related to technological learning in DCs, the author stresses that the causes of divergent learning performances among firms lie not only in the differences of strategy implementation, but also more significantly in the differences of their organisational learning systems. This does not imply overlooking the importance of investment in resource-based learning, grasping technological opportunities, training the labour force, etc. Rather, the author suggests the organisational learning system frames the learning activities of knowledge search, generation and accumulation. Technological learning of the DC firms should not be only regarded as a purposeful resource-consuming process, but also as an organisational process. The features of their organisational learning systems and their emergence should be placed at the very centre of our studies.

The theoretical contribution of the thesis is supported by its empirical studies of the Chinese car-making and telecom-equipment industries. Effective learning to gain the technological capabilities that enable DC firms to manage technological and product changes is observed in only a subset of firms (later to be called Group-B firms). For this point, the differences from other firm types will be examined at length in the course of this study. Detailed case studies are made to explore the association between their organisational systems and technological learning. Regarding the emergence of different views about technological learning and consequently different organisational construction, the author discusses this in a historical context, and attributes it to the evolution of Chinese socio-economic evolution.

1.2 China's technological learning

In China, catching up with the frontier countries in terms of the economy is a macro long-term mission for all of those who dedicate their efforts to the renaissance of the country. Before the First Opium War (1840-1842), China still produced nearly 1/3 of the total world output per year, ranking No.1 in the world (Maddison/OECD, 2001). However, the old decadent Chinese empire was overpowered by the pre-modern and modern western states. China's economic growth rate dropped from a level above the world average to one that was below it, or even retrogressed. China came to be one of the world's more backward countries. Thus, for more than a century, catching up with frontier countries again became a mission of primary importance for the legitimation of any Chinese reformer.

From 1953 on, when the new China distanced itself from the major wars started from the mid 19th century, massive industrialisation in a modern sense has been carried out in this country. By learning from comparatively advanced countries—first the USSR (Union of Soviet Socialist Republics) and other socialist countries, then the capitalist industrialised countries—as well as by mobilising internal innovation, industrial systems have been established. More and more people in Chinese society have been engaged in this industrial system, and have been carrying out technological learning generation by generation. Before they could learn significantly from western industrialised countries, China and its people had achieved 5.02% annual growth rates during the 1950-1973 period. With the "*43 Arrangements*" that started in 1972 and the "*78 Plan*" in 1978, China began to open its doors officially for massive international trade and cooperation with the industrialised western countries; it maintained a 6.8% annual growth rate during the period from 1973 to 1998 (Maddison/OECD, 2001).

Particularly during the past three decades, China's rapid rate of development has been widely acknowledged as a new successful example of industrial "catching-up". Large-scale production capacities have been established in the country, with the result that China is often termed the "world's factory". During this period, FDI (Foreign Direct Investment) and the bottom-up model of technological learning have been significantly encouraged by the Chinese government. The TMFT strategy dominated industrial policies for two decades starting from the mid 1980s. Chinese policy-makers had FDI as an important instrument fort reforming SOEs and promoting technological learning. In practice, SOEs were encouraged to set up Sino-foreign productive joint-ventures (JVs) with MNCs. For the TMFT framework, Chinese government invested in its elite resources, and provided a series of special treatments. In this way, Sino-foreign productive JVs established a large-scale manufacturing base in China. Additionally, in order to upgrade corporate governance, many SOEs passed the dominance of their organisational learning systems over to foreign partners, which means they reformed their organisations and underlying institutions according to the advice favouring "advanced models" suggested by MNCs. Most of them, if not all, began with assembling and manufacturing. They imported product designs and equipment from foreign partners and tried to learn from partners in the bottom-up manner of a technological life cycle. Some classical terminologies of bottom-up patterns have even become the slogan of policies in China. For instance, when the government of Guangdong province wanted Dongguan, i.e. a famous OEM (Original Equipment Manufacturer) cluster, to upgrade its industrial chain, the provincial government claimed that "*...Dongguan shall by 5-10 years of effort update its industrial development pattern from a labour- and capital-intensive one to a capital- and technology-intensive, or an exclusively technology-intensive one. During this, the mode of business should be changed from OEM to ODM (Original Design Manufacturer) and then to OBM (Original Brand Manufacturer)…*"[1]

The TMFT policy contributed significantly to the expansion of China's production capacity over the past two decades, and enhanced the legitimacy of this pattern in China's industrial community. According to official statistics,[2] the GDP (Gross Domestic Product) grew from 365 billion RMB (RenMinBi, Chinese currency) in1978 to 24,953 billion RMB at 2007 in terms of current prices. Considering fixed prices, compared to that of 1978, the GDP in 2007 is 15 times larger and the secondary industry is 24 times larger. Among the outputs of secondary industry, FFEs (Foreign Funded Enterprises) make up 31.5% with more than 23.5 million persons employed (data from 2007). Up to the year 2007, many industrial products manufactured in China ranked No.1 in the world. China exports a series of manufactured products, e.g. office and consumer electronics, garments, textiles, power equipment and vehicles, etc., of which it is the world's largest exporter. Moreover, there is another series of products with high global export rankings. The vast body of exports has very quickly created the largest foreign exchange reserves in the world.

However, China also faces less success in meeting all its catching-up targets. The growth of production capacity alone does not lead to the growth of technological capabilities. Even after two decades' practice of implementing TMFT policies, technological capabilities – i.e. the capability to "generate and manage technical change" (Bell and Pavitt, 1993, p159) – have not been obtained by these backbone SOEs and relevant Sino-foreign JVs. On the contrary, most of the previous capabilities in product development have disappeared from backbone SOEs in a number of industries. For many industries, China has obviously played a dependent role in corresponding global production networks. Take the TV set sector as an example: Chinese TV set manufacturers get core components, namely the IC (Integrated Circuit) chips and the LCD (Liquid Crystal Display) panels (there are precisely justthese two subsystems in today's TV set system), from some international suppliers. However, if the subsystems are updated, Chinese firms cannot get a supply of updated components until 4-6 months later. Suppliers provide the new subsystems to Japanese producers first because they are affiliated to, or have quasi-permanent technical cooperation with these Japanese TV set producers. The lack of in-house development capability

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[1] This was said by a regional governmental official of Guangdong Province in August, 2008, referring to *21st Century Business Herald*, 2008-09-05.

[2] The data of this paragraph are from the *China Statistical Yearbook* (2008), by the National Bureau of Statistics of China, China Statistics Press.

has Chinese manufacturers continually being placed in a position of *dependency*, even though they may have larger manufacturing bases with regard to their Japanese competitors.

At the macro level, being locked into the manufacturing section also creates unexpected outputs. The gap between GDP and GNP (Gross National Product) has been continually enlarging since 1978. By contrast with that in 1980, the GDP in China in 2007 increased by 17.4 times, but the GNI per capita only increased by 10.7 times. The remarkably uneven growth of GDP and GNP reflects the fact that China’s economy is still at the lower end of the biological chain globally. Relevantly, the problem of income inequality has also become worse and worse. The large base and rapid development of manufacturing require a huge amount of rural migrant workers, but they are just asked to fill low-paid, *Fordist* front-line jobs. In 2008, when the global financial crisis led to a reduction of demand for Chinese manufactures, hundreds of manufacturing firms were closed every month in either the Yangtze River Delta or the Pearl River Delta, i.e. the most important manufacturing bases of China. Correspondingly, millions of rural migrant workers lost their jobs because their weak manufacturing skills could not protect them from the crisis. According to the data published by the Ministry of Human Resources and Social Security, the numbers of going-back-home workers for the first 11 months in 2008 came to about 4.82 million, involving some 5.4% of the total rural migrant workers.

The delayed development of technological capability fosters a sense of defeat among many industrial practitioners and policy-makers, even after two decades of TMFT practice. For example, in the car-making sector, in 2003 when the author started investigating the empirical studies underlying this thesis, some national experts and consultants kept emphasising that the Chinese did not have capability to develop efficiently any engine, gearbox, bodywork or even an ABS (antilock braking system) indigenously. These core components were claimed to require huge technological investments to develop -- investments much greater than the resources that had been obtained at the time. Leaders from backbone SOEs also tried to insist on the lack of preconditions of resources for explaining why, legitimately, they could not present any indigenous product or critical technology innovation.

Facing the successful and unsuccessful experiences of this country, the Chinese policy-makers unavoidably encountered a series of industrial events that catalysed a controversy. Among these events was the intellectual property admission dispute related to DVD (Digital Video Disc) players that happened around 2004. The lack of core technologies obliged the Chinese DVD manufacturers, which were as prosperous as ever, to hand in huge licence fees, and to be confronted with severe global competition. The bankrupting of many domestic firms shook the policy-making community and society as a whole. Moreover, what heavily challenged traditional policy thinking was the rise of new indigenous firms. By comparison with the backbone SOEs and related JVs, they grew up independently of the central planning economic system, had not established Sino-foreign productive JVs, received less governmental support in their early phase, and had not followed the bottom-up pattern that emphasised the stretching of manufacturing capacity as a primary task. The most important distinction is that Group-B firms have continually carried out indigenous product development and constructed their competitiveness on such a process of technological capability building, which has not yet been realised by Group-A firms.

The car-making sector and the telecom-equipment sector are two of the typical cases that facilitate a distinct comparison of technological learning between Group-A and Group-B firms. In the telecom-equipment sector, new indigenous firms were mostly established from the late 1980s to the early 1990s, when on the other side productive Sino-foreign JVs were also actively built by backbone SOEs. After the "price war" of PDSS (Public Digital Switching System) during the late 1990s, new indigenous firms won an overwhelming victory over most domestic firms supported by the TMFT policy. Now the representative Group-B firms have become top competitors in the global industrial community. In the car-making sector, most Group-B firms were established in the mid and late 1990s, have now formed a major challenge to the incumbents in the domestic market, and taken a leading role in car exports.

Around 2004-2005, an important controversy arose among Chinese industrial leaders and policy-makers. The emergence and rapid growth of Group-B firms provided another strand of thinking regarding the idea of catching up for the society as a whole. In 2005, "indigenous innovation" and the "quality of growth" were put forward by the Chinese central government and formalised in the "National Guidelines on Medium- and Long-Term Programs for Science and Technology Development (2006-2020)" in 2006.

However, even though Chinese policy-makers have realised the difference between "production capacity" and "technological capability" (Bell and Pavitt, 1993), technological capability does not emerge so automatically. The Chinese government has supported a series of projects, such as the EVD (Enhanced Versatile Disc) standard in the digital video player sector, the WAPI (Wired Authentication and Privacy Infrastructure) standard for the wireless LAN (Local Area Network) equipment sector, etc; meanwhile, many large SOEs that are involved in the TMFT framework have announced projects to develop indigenous systemic products. However, many of them are confronted with difficulties in attaining rapid industrialised outputs; few of them have achieved their targets of technological innovation until now.

1.3 Academic explanations

Many scholars have attempted to explain technological learning in the context of industrial development. The new trade and growth theories, including those of Romer (1986) and Lucas

(1988), aim to include technological change in modelling economic growth and take on the concept of "learning by doing" developed by Arrow (1962). However, this usage presents several difficulties. Its strict presumptive conditions make it difficult to interpret the complicated empirical dynamics; and for its basic model of knowledge-generation, it is difficult to explain any other kind of disruptive technological change in addition to incremental experience-based change. Even though scholars go forward to include imperfect competition and R&D (Research and Development) in their frameworks (Romer, 1990; Grossman and Helpman, 1990; Aghion and Howitt, 1992), as inspired by Schumpeter (1947), they are still obsessed with explaining "what if" questions. Without exploring micro-mechanisms of knowledge searching, generation and accumulation, these theories cannot prove their robustness when tested with diversified empirical development across countries or even within a single national economic system. Their explanations still in essence take innovation or knowledge as the free good or by-product of production (Fagerberg, 1994, p1170). For example, they have to deal with the difficulties in explaining the convergence or divergence of empirical observations regarding economic development (Abramovitz, 1986; Baumol, 1986).

Other scholars have explored the different industrial patterns among different countries (Chandler, 1990). The influences of institutions are taken as key factors in shaping the specific patterns of different countries (Whitley, 1999, 2002), so are the social conditions (Lazonick, 2010). The "embeddedness" of microeconomic behaviour within a set of social relationships, rules, and institutional constraints can cause firms within the same social context to exhibit some commonalities (Granovetter, 1985). Furthermore, embeddedness contributes to determining the evolution of organisational structures, competencies, and strategies (Coriat and Dosi, 1999, p104). Therefore, it is not difficult to accept that the national patterns of industry are shaped by a complex system of social power, governmental policies, and the actions of leading enterprises (Lazonick, 1990, 1991; Best, 1990). In the field of technological learning and catching-up research, this has been recognised by researchers such as Enos (1991, pp3-4). According to some cross-country studies, other scholars again provide empirical evidence that even the same industrial policies can lead to different results in different developing economies (Forbes and Wield, 2002). Differences in catching-up pathways have also been suggested for countries with similar culture in the same region (Lee, 2005). In practice, even academic communities and policy-makers prefer different policies for catching up in the face of the different cases they are talking about (Forbes and Wield, 2002, p45). Given this and given the empirical studies of China's rapid development, we accept the argument that the relationships among institutions, learning patterns, and catching-up outcomes may be country-specific, and deeply involved in the relevant social, institutional and organisational contexts.

Even with the recognition of diversified patterns of countries, it is also unacceptable to assume that at firm level, DC firms would definitely adopt highly similar patterns of learning unless there is empirical evidence that they develop similar views about learning and business operations. A reason why the successful experience of catching-up firms could be regarded as generalisable may reside in the limited attention that we pay to a particular category of successful firms only, rather than all kinds of developmental attempts; or because a similar explanatory framework is applied prior to obtaining the empirical facts. Thus, studying the differences among DC firms is important for understanding the relations between learning patterns and learning performances, which is close to the source of dynamics of their capability growth, and corresponds to the study of frontier firms in more industrialised circumstances (Nelson, 1991).

This thesis is mainly developed based on, and argued with, the literature on technological learning at firm level and in the DCs. In the past three decades, a variety of research has been undertaken to explore the development process of firms in DCs in terms of technological learning (such as Katz, 1987; Lall, 1987; Enos, 1991; Hobday, 1995; Leonard-Barton, 1995; Kim, 1997; and Figueiredo, 2001), which are termed "assimilation theories" (Nelson and Pack, 1999). Countries, industrial clusters, industries and lie at the centre of the above studies. Most of them emphasise technological opportunities, enterprise strategies, learning pathways, strategy or project implementation or productivity with reference to technological learning. The diversification of technological learning at firm level has been highlighted only in recent years in terms of the productivity of learning (Hwang, 1998; Ariffin and Bell, 1999; and Figueiredo, 2001). In other words, organisations are usually studied only for their different forms of implementation of learning; they are put forward as givens or as a bunch of resources, individuals, strategies and reactions to policies. It is their methods of implementation rather than themselves as organisations that are studied. The former point, usually represented as pathways, opportunities, specific programmes, etc., is used to explain the different performances of technological learning and catching up.

Based on given organisations, by and large, the micro-mechanism of knowledge generation and accumulation is explained as relying on resource-centred assimilation programmes. For example, the programmes of importing technology from advanced countries, employing people from outside, continually training employees, and upgrading of equipment are often adopted in the conventional literature as methods to analyse the dynamics of obtaining, extending and accumulating knowledge. For the rest and non-resource-centred factors, the narrow sense of "learning by doing" or the DUI (doing, using and interacting) mode of learning/innovation (Jensen et al., 2007; Lundvall, 2007) takes on an important role in interpreting continual and incremental knowledge growth. However, in practice, when the DUI mode of learning is manifested clearly, scholars mostly again adopt the resource, human effort and time investment as measures. Or they just base the analysis of non-resource factors taken from narrative description.

For example, cultural characteristics, e.g. a tradition of valuing hard work within a particular society, are often considered as important in explaining the residual of contingently high efficiency of learning in successful countries or even firms.

In short, the conventional wisdom about technological learning in DCs is mainly based on the tradition of the Resource Based View (RBV). This means that the central argument that they focus on is the implementation generated by the organisations in question, or the "*service*" in Penrose's (1959) term. In particular, knowledge is regarded as the output of relevant investments through the "*service*".

By contrast, this thesis more persistently focuses on the differences between organisations. This does not mean that we overlook the implementation of strategy, resources or learning. However, we stress that the conventional assimilation theories derived from (and also limited by) RBV cannot explain well the substantial dynamics of technological capability building of DC firms, especially in explaining the divergence of technological learning in DCs. Successful technological learning cannot be simply regarded as the firms in question making the right decisions, carrying out the right projects, or investing sufficiently. Otherwise, we cannot provide any *ex ante* implications for the catching-up of latecomer firms because our theory has to depend primarily on particular organisational and institutional settings that are platforms to implement corresponding projects and strategies.

Thus, we aim to develop the analysis from studying the organisations themselves, to gain greater understanding of the building of organisations, the resource allocation within firms, the process of technological learning and the knowledge management system in the circumstances of developing countries. We argue that technological learning, at least that of catching-up firms in DCs, is closely influenced by their organisational systems, namely by their strategic intent, authority over strategic resource allocations, patterns of organisational mobilisation and learning integration, and their facilities and institutions for knowledge accumulation.

1.4 Implementation of this research

The empirical studies for this thesis began in 2003 and consisted of a series of research projects. Some of the projects were commissioned by the central government of China, which helped to open the door to enterprises, and become one part of the policy controversy there during 2004-2005.

During the several years' worth of empirical studies, five manufacturing industries were involved in our studies, including the car-making sector, the telecom-equipment sector, the construction machinery sector, the power equipment sector and the consumer electronics sector. For reasons of brevity in elaborating case studies at firm level, we only pick two sectors in this thesis. The car-making sector and telecom-equipment sector are selected for their distinctive differences as well as their common features. On the one hand, this selection protects our research from being distracted by particular industrial characteristics derived from high-tech or traditional technologies, or by particular producer-user relations; car-making is broadly regarded as a traditional industry for the mass consumption market while telecom-equipment manufacturing is usually included as a high-tech industry with outputs of capital goods. In terms of technical change, the car-making sector and the telecom-equipment sector also belong to different categories, namely the production-intensive and the science-based respectively (Pavitt, 1984). Putting them together helps to reduce the bias caused by special industrial patterns. Besides, the emergence of new indigenous firms in these two sectors clustered in different time periods. To study them together also helps to tell whether highly sector-specific policies in the short term determine fundamental patterns of technological learning at the firm level.

On the other hand, the two sectors share important commonalities. There are successful new indigenous firms that emphasize in-house product development in both sectors; and these firms manifest sharp contrast with those incumbent backbone SOEs and their productive Sino-foreign JVs in terms of technological learning.

In short, bringing the two sectors together helps us to identify the substantial diversity of industrial firms in China at the organisation level, which is regarded by the author as critical in understanding the dynamics of capability building of DC firms.

Assisted with other methods, our empirical studies are carried out mainly by on-site fieldwork at the firm level, especially by face-to-face interviews and participatory observation (see the List of Interviewees for details). The studied firms are put into two categories according to their strategies and performances of technological learning. Comparative study is carried out to analyse their organisational learning systems; we also go further and present an in-depth investigation into the role played by organisational systems in their knowledge creation processes.

1.5 Outline of this thesis

The thesis consists of nine chapters. This first chapter is the introduction to the whole thesis. Here we briefly present the empirical background, the most relevant academic discussion and the implementation of this research project.

In the second chapter, conventional research works are reviewed. The literature concerning technological learning and catching-up in DCs is the major field of research with which we engage. The relevant studies focused on China's development are also involved in this chapter.

The third chapter covers the research methods. In that chapter, the central question and the hypotheses are highlighted. We discuss the methods employed in our empirical study and, in detail, the execution of our research plan.

In the fourth chapter, the institutional and industrial backgrounds for the sectors we study are elaborated on. Historical studies about the source of original patterns of Group-A and Group-B firms are introduced.

The fifth chapter carries out comparative studies of the two groups of firms. Strategic intent in technological capability building and the activities carried out by these two groups of firms are the major perspectives through which we discuss the differences of technological trajectory.

The sixth chapter is a follow-up of the fifth to continue the comparison between these two groups of firms. Chiefly, authority over resource allocation, patterns of organisational mobilisation and learning integration and knowledge databases are discussed.

The theme of the seventh chapter is to explore the in-depth relation between the organisational learning system and the process of knowledge creation. All the empirical studies in this chapter are based on Group-B firms.

Chapter 8 revisits the evolution of management patterns of Chinese industrial enterprises. We aim to link the differences between organisational learning systems with the revolution of institutions in China. By doing so, we argue that organisational systems of firms are closely related to the societal development and political evolution in corresponding DCs; then organisational learning systems should be taken as primary mediums for the studies of technological learning and catching-up in DCs. After that, we reconsider the conventional wisdom, and put forward our theoretical arguments.

Chapter 9 concludes. The hypotheses are tested in the chapter; conclusions and implications for policy-makers and academic researchers are put forward.

Chapter 2. Literature review: technological learning and capability building in DCs

2.1 Introduction

The purpose of this chapter is to locate the research for this thesis within conventional intellectual contexts. By reviewing the classical literature in relevant academic fields, we can highlight the research question of this thesis and its potential importance for understanding the development of catching-up countries, or at least that of China during the past three decades.

The discussion will focus gradually toward such a question about how industrial firms in DCs build up their technological capabilities. Considering the divergence of technological learning performance not only among different countries, but also among industrial firms in the same country or the same national innovation system, we place the organisational factors as the central inquiry for influencing technological learning when reviewing the relevant literature. Additionally, we also aim to find clues from conventional wisdom about how the firms recognise learning, and how they construct their organisation for learning.

We will argue, through the following sections, that scholars have already accumulated much knowledge about the historical analysis of catching up at country level or at industry level, and have also built some understanding of individual firms or industries about how specifically they implement technological learning successfully. Only a few studies have explored why the performances in learning could be disparate between different subsets of firms in particular industries. If both the success and the failure of learning are attributed to the implementation of strategies or projects, it raises a corresponding question for us to answer, of why different subsets of firms conduct dissimilar strategies and work differently in learning projects. As an alternative, we shall explore how the organisational learning systems of the firms are constructed, and how they influence knowledge accumulation.

In section 2.2, the discussion focuses on the conventional wisdom about technological learning and catching up. Section 2.3 reviews the literature on China’s development at the firm and industry levels. Section 2.4 discusses the literature on the role of organisation regarding technological learning in DCs.

2.2 Technological learning in conditions of development

Technological learning has been generally regarded as the core source of technological competences not only in the literature about frontier firms in developed countries but also in literature about catch-up firms in DCs. However, in DCs, technological learning is confronted with at least two special realities that are not so pervasive in the developed world. Firstly, in DCs, firms are short of technological knowledge, both in terms of absolutely new knowledge, and of knowledge existing in the developed world, as would be necessary to generate helpful knowledge accumulation. Secondly, the process of catching up entails latecomer firms' progressing from a low level to a high level in terms of capability. Therefore, the process of technological learning must be a dynamic one. In other words, latecomer firms are obliged to demand "new-new" technologies continually so that they can progressively enhance their technological capabilities and shorten the gap between themselves and frontier firms.

In this section, the discussion of the relevant literature is organised into three main parts. Firstly, we discuss the phenomena and themes that researchers study which are most relevant to the field of technological learning in DCs. Secondly, we consider the "what" (to learn) question, the "who" (to learn) question, and the "how" (to learn) question of the technological learning process. We also place the knowledge about learning itself in the foreground: how firms in DCs recognise technological learning, and how they establish their mindset about the relationship between learning patterns and learning performance. Thirdly, from considering the various relations among knowledge sources, knowledge accumulation and organisational systems, we highlight the question of the effectiveness of technological learning.

Through the three parts of the review, we attempt to develop a perspective regarding the relationship between organisations and the mechanisms they adopt for technological learning. Such a perspective is to be a central concern of this thesis, namely the capability growth of technical integrators in DCs, and the relevant divergences of learning performance among them and their local competitors.

2.2.1 Historical studies of catching-up: rapid industrialisation in latecomer countries

Catching-up by DCs has been a traditional topic in the field of development research and policy controversies. The relevant discussion has already been developed from the new industrialised countries, such as Germany and Russia, to the "new-new" industrialised countries such as Japan and NICs. Now the discussion has been spread to cover more industrialising or potentially industrialising countries. Most theories can be traced back to Veblen (1915 [1974]) and Gerschenkron (1962). Veblen argues that technological changes can be transmitted in definite and unequivocal shape. The forms of technological transfer which he advocates include the immigration of skilled personnel and the purchase of machine tools with new technologies embedded (Fagerberg and Godinho, 2005). Gerschenkron (1962, p47) agrees: *"the existence of the more advanced countries as sources of technical assistance, skilled labour, and capital goods"* may prove crucial for the backward country's obtaining prerequisites to industrial development.. The creation of latecomer activities, and of substitutions for the "prerequisites" (or the utilisation of existing "prerequisites" from foreign sources), which Gerschenkron regards as specific institutional responses to the technological gap, are emphasised as critical for successful catching-up. Central to his observations on institutional conditions for catching up are those to mobilise resources and to concentrate the resources in large-scale investment in producers'-goods sectors (i.e. capital goods). For this purpose, the role of the banks in the German case and of the government for financial accumulation and appropriation in the Russian case are underlined. The strategies that Gerschenkron advocates can be summarised (e.g. by Sylla &Toniolo, 1993) as: firstly, catching-up countries should target rapidly growing and technologically advanced industries; secondly, intensive investment in existing mature technologies/industries is recommended, by which catching-up countries can benefit from scale economies in production.

Regarding the macro-level analysis, Abramovitz (1979 [1989]; 1994) agrees on Gerschenkron's point about the latecomer's advantage and the institutional preconditions for catching-up. Indeed, according to his definition of technological congruence, he also prefers the strategy of investing heavily in industries with scale-based technologies. In his framework, Abramovitz develops the terminology of "potential" for catch-up of latecomer countries by defining the technological/ productivity gap as its first component. Technological congruence, as the second, refers to the status of being similar and convergent in terms of factor supplies, markets and production scales between the developed countries and those catching-up (Abramovitz, 1994, p88). However, he stresses that this will not be automatic. Social capability, as a third component of the "potential", refers to the qualitative development of technical competence, including that of education and the political, commercial, industrial, and financial institutions (Abramovitz, 1986, p388). The realisation factor of catching-up includes the conditions controlling technological diffusion across countries, conditions influencing structural change and the stability of macroeconomic backgrounds that support relevant investment and technological absorption (Abramovitz, 1994, pp88-89).

Abramovitz's framework is mainly criticised for ambiguities in defining "social capability" and the causal relations of his approach. As for the former, he includes people's basic social attitudes and political institutions, education, competence in the organisation and administration of large-scale enterprise, capital markets and intermediation, which comprises a broad range of quality measures (Abramovitz, 1995). Therefore, as for comparative studies among countries, Abramovitz (1986, p388) himself admits "*...the trouble with absorbing social capability into the catch-up hypothesis is that no one knows just what it means or how to measure it*". The ambiguity ties this theory more closely to a *post hoc* framework to interpret the success or failure of countries' attempts at catching-up. As he mentions, education levels are only a rough proxy (see also Baumol, 1986). However, considering the different situations of catching-up (even for just the successful cases) it is obviously insufficient when it is applied to other countries, such as

Korea (Shin, 1996). Besides, their analyses rely heavily on aggregate data, and particularly on the averages across countries. Thus, even if other factors could be all included as "social capability" and applied to the analysis of averages, a number of factors will demonstrate different features in different countries, such as governmental intervention. Besides, Abramovitz's framework is also controversial for whether the social capability is developed (or began to develop) earlier and is independent of technological/productivity catching-up, or occurs simultaneously. It is not only a question related to historical studies (Shin (1996) – but also a question of causality: whether social capability is the driving force of catching-up, as it is defined to be one component of the "potential", or is a force that co-evolves and deeply interacts with the successful catching-up process.

The historical studies of "catching-up" can provide us helpful frameworks, but only as reference to consider the ongoing industrialisation process of DCs. As noted by Gerschenkron, each latecomer economy may face very different external environments in terms of markets, technologies and opportunities. Therefore, it is not acceptable that every catching-up case should be based on the same set of preconditions (Gerschenkron, 1962; Hobday, 2003, p294). Therefore, the process of industrial development of latecomer countries ought to be regarded according to their own circumstances. Accordingly, Shin (1996) explains Gerschenkron's substitution of prerequisites as the "functional substitutes", rather than the simple transplantation of successful countries' institutions. By doing so, Gerschenkron's approach can be applicable to more general cases. Otherwise, if the analysis of institutional transplantation, theoretically or practically, is not based on the real specific temporal and spatial conditions, the approach from the above historical perspectives is very likely misused. For example, economists with the dependency view, such as Cardoso (1978), argue that the practical way of DCs to acquire advanced technologies, namely to rely on MNCs and external market, would have the industries of latecomers develop in an incomplete form[3].

Therefore, in order to generate better understanding of rapid capability-building in DCs, we shall focus more on the process of industrial development and technological learning at firm-level and industry-level. As pointed out by Teece (2000, p124), considering the relationship between the industrial firms and the development of newly industrialising countries, the study of economic development cannot take place separately from studying the theory of the growth of the firm. As knowledge has been generally regarded as the core of economic development and technological learning is taken as the central means to accumulate knowledge, therefore "*…the key to success is, rather, rapid learning and forgetting (when old ways of doing things get in the way of learning new*

[3] Quoted from Warren (1980), p181-182. The original source is "Cardoso, F.H. 'Some New Mistaken Theses on Latin American Development and Dependency', mimeo, October 1973, p. 29, n. 13."

ways)" (Lundvall and Archibugi, 2001, p1). More attention ought to be paid to technological learning at the firm-level and industry-level for generating better understanding about catching-up by DCs grounded in both historical and ongoing experience.

2.2.2 Empirical studies of technological learning in DCs: objectives

Here by the empirical studies of technological learning in DCs, we refer to those that place learning about new technologies and learning to master them as central in the analyses and focus on what was involved in this achievement (Kim and Nelson, 2000, p2).

For at least the past three decades, there have been groups of scholars contributing their insights as regards technological learning in latecomer countries. Initiated by Katz and his Latin American team (Katz, 1987; Bell, 2006), relevant studies focus on the "what" question (Figueiredo, 2001, p2) of technological learning and the relevant change of "what" over time, although the question of time scale has not been explicitly discussed yet (Bell, 2006). Among the relevant literature, some have concentrated on issues related to the choice of technologies (Enos, 1982); many have centred on issues regarding paths of technical change, trajectories of capability accumulation (such as Lall, 1987; Enos, 1991; Hobday, 1995; Leonard-Barton, 1995; Kim, 1997; Figueiredo, 2001; and Forbes and Wield, 2008), and external forces shaping these trends (Katz, 1987).

As mentioned above, the works of Gerschenkron are an important source of technological catch-up studies for the academic community. Gerschenkron (1962) emphasises that latecomer countries can implement existing mature technologies, thereby immediately initiating economies of scale production. Amsden (1989) and Kim (1997, 1999) underline the strategies for adopting existing technologies and stress the importance of large-scale firms. But in some cases, considering the "maturity" of existing technologies, the technological learning or the inward transfer, absorption and assimilation is discussed in the same simple terms as the transfer or imitative construction of physical capital, or additionally as implied by Veblen (1915 [1974]) and Teece (1977) as the transfer of people for tacit knowledge. This may bring about a simplified understanding of technological learning. Amsden, in her study on Korean industries, even defines learning in DCs as "… *[these countries industrialized] by borrowing foreign technology rather than by generating new products and processes*" (Amsden, 1989: preface, v), which is generally considered the "late development advantage".

More researchers have opinions opposing Amsden's definition of "technological learning" in newly industrialising countries (NICs). Firstly, all researchers who adopt the concept of "absorptive capacity" deny this simplified statement of technological learning. Relevant researchers argue that technologies rarely can be embodied in a "book of blueprints", and even more rarely transferred as such. International technology transfer, like domestic technology transfer, is a costly, time-intensive, and knowledge-intensive process (Mowery and Oxley, 1995, p69). Through empirical studies, Enos and Park (1988) demonstrate that effectiveness of incorporation of foreign technology into DCs rests on multiple factors at different stages. They argue even the precision of technical terms obtained by the importer would also remarkably influence the success of technology absorption. By studying the case that Chinese invested in large plant and made use of foreign technologies, W. Liu (1992) demonstrates exactly that technology importers have to do more than just acquire physical facilities and the skills associated with using these facilities. Bell and Pavitt (1993) point out that it would be difficult for catching-up countries to install large plants with foreign technologies because DCs also lack the absorptive capacity necessary to transfer the technologies onto the human capital stock. Thus they emphasize "*the complementarily between technology imports and local technology accumulation*" for the technological capability building in DCs (Bell and Pavitt, 1993, p193). Freeman and Soete (1997, p356) point out that the use of foreign, imported technology is not a straightforward "industrialisation" shortcut. Radosevic (1999) support the view of Freeman and Soete with regard to the experience of Central and Eastern Europe. As for learning by co-operating with MNCs, Sölvell and Zander (1999) also introduce mechanisms of MNCs to isolate local innovation systems with their mainstream knowledge creation. Considering the technology diffusion from foreign sources, by an aggregate data analysis in Venezuela, Aitken et al. (1999) find that although foreign equity participation can promote the productivity of small-sized firms, foreign ownership negatively affects the productivity of domestic owned firms in the same industry. And the technological spillover from foreign firms to local firms has not been found to happen automatically. Even scholars (Blalock, 2001; Damijan, et al., 2003) have generally testified vertical technological transfer from FDI within the industrial chain involved in DCs; many scholars also applaud the opinion that horizontally FDI participation has a regressive effect on local firms' productivity (Kokko, 1994; Aitken et al., 1996; Aitken and Harrison, 1999; Blalock, 2001). The squeeze effects caused by the FDI capturing local talent and local market reduce the economies of scale of local competitors. Such effects are taken as important sources for the problems of domestic firms in acquiring technologies through learning from FFEs. Besides, the technological gap between FDI firms and domestic firms, and the absorptive capability of the latter, as well as the measures adopted by FDI to prevent technological leakage, are also taken into account. In fact, even Amsden herself also realises this point later, and adopts the term "crowd-out" to describe the squeeze effect caused by FDI over domestic national firms (Amsden, 2001, p191).

Therefore, even though in theory DC firms can make use of the existing mature technology and invest intensively in large scale plants, effective technological learning or successful technological inward transfer would not naturally come into being. The supportive institutions of DCs and the knowledge accumulation process of latecomer firms will still need to be studied as the central topics.

The “product life cycles” model (Utterback and Abernathy, 1975; Abernathy and Utterback, 1978) provides another very important analytical instrument for studying technological learning. The “product life cycles” model can be traced back at least to the contribution of Hirsch (1965) and Vernon (1966). The model divides the product life cycle into several phases in terms of technological maturation. For each phases, there would be different comparative advantages between the newcomer and incumbents, and different levels of technological risks. Therefore, it entails academic space for researchers to develop specific catching-up strategies for each phase. Such an analytical framework is adopted at least by two kinds of approaches related to the technological learning in DCs.

Firstly, scholars develop a framework based on the techno-economic paradigm to understand the technological entry barriers for latecomers and the opportunity windows for catching up (Soete, 1985; Perez and Soete, 1988; Freeman, 1989; and Freeman and Soete, 1997). Apparently enlightened by Dosi (1982)’s analysis of technological paradigm, this framework implies that the technological and economic development could be viewed as cumulative and continuous. However, as for the shifts from one techno-economic paradigm to another, the technological and economic development would be destructive and discontinuous. As for the cumulativeness and continuity of technological and economic development, DC firms are advocated to invest heavily in manufacturing standard products, making use of the existing mature technologies and economies of scale. Besides, more emphasis is placed on the periods of the shifts of the techno-economic paradigms. At that moment, theoretically (by this framework), forerunners’ advantage, embodied as their investment and accumulation in the relevant facilities and institutions --- which Christensen terms the “value network” (Christensen and Rosenbloom, 1995; Christensen, 1997; Christensen and Raynor, 2003) -- cannot act as it does during the stable period. On the contrary, the previous accumulation and investment turn out to be burdens to some extent on sunk costs. By contrast, latecomers from DCs have no such sunk cost as burden so that they can move faster and more efficiently. Available public knowledge, usually carried out by universities, is a critical factor to facilitate latecomers’ catching up in the early stage of paradigm shift.

The advocacy that DC firms can take up the opportunity windows of a techno-economic paradigm shift coincides with research in frontier countries about the discontinuous technological change and accordingly the advantage of attackers (Utterback and Kim, 1985; Foster, 1986; Henderson and Clark, 1990; Tushman and Rosenkopf, 1992; Utterback 1994; Christensen and Rosenbloom, 1995; Utterback and Acee, 2005).

The catching-up framework based on “entry barriers” and “product life cycles’ has been developed continuously. For instance, taking the empirical study of several industries in Korea as examples, K. Lee and Lim (2001) outline three major strategies for technological catch-up: stage-skipping, path-creating, and path-following. In their research, the two authors extend the concepts, comparing with the two opportunity windows put forward by Perez and Soete (1988). They highlight that through the active efforts by the government of DCs or the industries/firms, latecomers could create disconformities of technological trajectory with those of industries in advanced countries. This means latecomers speed up actively along the existing trajectory, or create a new trajectory so that they can enter a new emerging stage or a new technological trajectory. Hereby, through earlier investing in the new stage, or new techno-economic paradigm, latecomers may have chances to obtain advantages by contrast with firms in advanced countries. Furthermore, in order to shed light on the transition phase of latecomer firms in developing high-level capabilities, J. Lee (2007) generates a model of experienced catching-up that consists of imitation, deviation, and generation phases.

However, the catching-up analytical framework based on “entry barriers” and “product life cycles’ is also broadly questioned, such as by Kaplinsky (1989) and Ernst and O’Connor (1989). Criticisms usually come from the heuristics of empirical observation that historically the gap between advanced countries and DCs would tend to reopen again. Accumulation in the previous techno- economic paradigm can be regarded as a burden or sunk cost to some extent; however, it could be the foundation for the new techno-economic paradigm for the connection between the old and the new industries as well. Flexibility of production systems, economies of scale and science intensity are more likely to be the advantage of advanced countries to utilise the coming techno-economic paradigm. Therefore, even though opportunity windows could exist during the period of paradigm shift in theory, it is often not wide open enough for latecomers to accumulate so many industrial infrastructures and social capabilities to realise successful catching-up. Besides, the availability of public knowledge to DCs in the early stage of paradigm shift is also broadly questioned.

By his historical perspective of catching-up, Shin (1996) comments that the theoretical framework of Perez and Soete does not fit the actual history of catching-up very well. Catching-up is a historical phenomenon determined by the combination of characteristics of technologies and responses on the part of latecomers so that the emergence of catching-up would not solely rest on the technological entry barriers.

We shall raise another one criticism here. Supposing that the theoretical opportunity windows do exist, we still have to interpret the divergence of technological learning among DC firms under the same or similar contextual environments. We shall question why some firms (or countries) seize the opportunity while others are unable to do so, especially considering the fact that the winners are always exceptions compared with the vast number of firms in similar circumstances. The stress of divergence moves the determinism of technology away from the centre stage of catching-up inquiry, and replaces it with the institutional and organisational conditions for effective learning. It is the firms that are ready to seize the opportunities which would finally do so. The point here is that it is not the entry barriers or opportunity windows that make these firms/countries ready.

Another important application of the "product life cycles" is developed in a step-wise explanation of the technological capability ladder. In general, the adoption of this kind of explanation is not really based on the "product life cycles" at the unit/technology level, but is extended to the firm-level, industry-level and country-level. The "product life cycles" framework is adopted to achieve a clear comparable connection between developed countries and DCs (J. Lee, Bae and Choi, 1988). In fact, it is set up to describe the evolutionary process of capability-building in DCs: technology learning starts with labour-intensive assembly, and reaches the level of assimilation, improvement, and product design only at a much later stage, and finally arrives at a stage of knowledge creation based on in-house R&D.

The different capabilities in a step-wise mood are summarized by Fransman (1984, p10) as "*the search for available alternative technologies and the selection of the most appropriate technology; the mastering of the technology, that is its successful use in the transforming of inputs into outputs; the adaptation of the technology in order to suit specific production conditions: the further development of the technology as the result of minor innovations; the institutionalised search for more important innovations with the development of R&D facilities; the conducting of basic research*".

As an early attempt of this kind, J. Lee et al. (1988) review relevant research during 1960s-1980s, and demonstrate many of them by adopting the bottom-up stage-wise models. Based on the above work, J. Lee et al. develop a three stages model for understanding the capability-building of DCs, namely the "initiation – internalisation – generation" sequencing stages, corresponding in reverse to the "fluid -- transitional – specific" sequencing stages in Abernathy and Utterback's model. This framework is adopted and developed by Kim (1997, p86-90, p210) in his classical studies of the industrial catching-up of Korea, in which Kim advocates the "acquisition – assimilation – improvement" model. At the acquisition stage, with the foreign technological assistance, latecomer firms learn to assemble foreign standard, undifferentiated goods. By doing so, latecomers aim to implement the technological transfer from foreign partners for manufacturing operations. At the assimilation stage, production and product design technologies are supposed to diffuse quickly within the latecomer firms and latecomer countries. Then latecomer firms are able to develop related products through imitative reverse engineering without the direct transfer of foreign technologies. The third stage, namely the improvement stage, is based on the successful development of the previous two stages, and the increased capability of domestic scientific and engineering personnel. Scholars suppose latecomers can gradually improve the technologies; imported technologies can be applied to different product lines through domestic efforts of R&D and engineering. And the third stage if the study is at country level, where latecomers are believed to develop into industrially developed countries (J. Lee et al., 1988, p242-243; Kim, 1997, p89-90).

As demonstrated above, by contrast with Abernathy and Utterback's terms in describing the technological evolution, the terms of acquisition, assimilation and improvement are also meaningful for understanding the evolution of capability-building at different levels. Besides, this framework includes latecomer learning that takes place not only in mature technology in the specific stage but also in growing technologies in the transition and fluid stages (Kim, 1997, p90). It extends the temporal coverage of bottom-up stage-wise models. Therefore, this framework is successfully applied to different firms, industries, and even countries. Besides, it brings an intuitive embodiment of the strategy advocated by Gerschenkron, his followers and relevant historical experiences that DCs (can) invest in foreign existing mature technologies, and secure development through incremental progress.

Bottom-up patterns are broadly adopted by scholars (Enos, 1991; Kim 1997; Leonard-Barton, 1995; and Figueiredo, 2001). One of the core topics for bottom-up research is the ladder of technological capability building. These ladders have two strands: one stresses the level of capability, usually associated with the analysis of each stage; the other is developed based on functions, namely the sets of activities learning firms are able to implement. For brevity, we only mentioned some of them here. Two of them are very much worth mentioning for their representativeness. One is Lall's capability-building matrix of manufacturing industry in DCs, which combines both lines (Lall, 1987, 1992, 1994). With this matrix, similar to what Kim and Lee et al. do, Lall describes a process of latecomer firms develop gradually from simple capability to complex capability. For each stage, Lall points out six major functional segments, namely the project preparation/pre-investment, project execution, process engineering, product engineering, industrial engineering and technology transfer/linkage within economy. His matrix is supported by his empirical studies on a series of Indian industries, including cement, steel, textile and some special case studies in other industries. Even Lall points out that for different industries, the real paths can be divergent, particularly considering specific stages. However, Lall insists, "*mastery would proceed from simpler to more difficult activities, different firms and different technologies adopt different sequences*" (Lall, 1994, p267) – he still implies that different paths of firms will follow the general ladder from the low level to the high level. Since his framework includes two dimensions: the dimension of capability complexity and the dimension of functions. The dimension of capability complexity is also in effect a time sequence dimension since relevant scholars advocate the bottom-up mode. Therefore, this matrix depicts a spiral growing trajectory of latecomers' capability-building in DCs. Lall's matrix is broadly adopted such as by Bell and Pavitt (1995, p83-84). Figueiredo (2001) also modifies and improves Lall's ladder by adjusting the definition of functions and categorising the complexity (time) dimension into routine level capability and innovative level capability.

Hobday (1994, 1995, 2000, and 2003) combines studies of technological transition and industrial opportunities with empirical studies of the electronics industries in East Asian countries and South East Asian countries. His research focuses on inter-firm relationships during fast industrial development in an export-oriented environment. The relation of local firms with foreign technological sources and with the supply chains are the key of his research. In these studies, Hobday summarises an "OEM -- ODM -- OBM" ladder of latecomers' strategies and activities (see Hobday, 1994 or Hobday, 2003, p298). This well-recognised framework successfully connects the technological learning of DCs with industrial globalisation in the past few decades, and depicts the macro-change of relevant countries.

The studies based on bottom-up stage-wise models have already provided prolific empirical analyses of firms and industries in DCs, particularly those from Korea, Taiwan area, East Asia as an analysed area, South East Asia, South America and some countries in Africa. These studies enrich our understanding of the processes of latecomers in DCs gradually building their capabilities incrementally. However, for the sake of theory generality of these models in studying the empirical cases of DCs, we still have to emphasize several points, especially considering the popularity of these models, as follows:

First, we should consider the spatial generality of the bottom-up stage-wise models. Following Gerschenkron's statement that different countries would follow divergent paths of catching-up, some scholars also claim that this ladder is only suitable for a specific industry and catching-up stages would be different across countries (Hobday, 2003, p299-300). In fact, J. Lee et al. (1998) also identify four types of national patterns of technology development. Among the four types, their framework is appropriate in describing the imitative-learning type of development process such those in Korea and Taiwan only (J. Lee et al., 1988, p239-240). Therefore, to extend the generality of models to different countries and industries or to study the divergence of catching-up remains an academically important task.

Second, the temporal generality of these models should be thought over. The patterns of catching-up not only vary with different countries, but also vary with different temporal global industrial environments. For example, with rapid technical change, globalization and policy liberalization, the context for industrial development is changing radically. So it is becoming imperative for DC firms (whether they serve domestic or foreign markets) to be internationally competitive (Lall and Pietrobelli, 2002), which may represent a difference from the catching-up experiences of Japan and Korea. Even for particular cases, the continuous progress and relevant change of industrial positioning of learning subjects may also bring about different situations than observers ever studied and built their theoretical framework on. For example, the “strategic dilemma” put forth by Hobday, Rush and Bessant (2004) in studying the catching-up process of Korea reflects both the dilemma of industrial practitioners and the dilemma of observers in developing theoretical explanation: Korean firms face prominent difficulties when they aim to move from ODM to OBM; for observers, the micro-mechanism in stage models is difficult to generate to explain such a jump.

Third, the divergence of firms should also be regarded as a necessary part of our studies. Divergence of learning performance in general exists among latecomer firms even if they implement similar strategies. However, there is only limited research involving any discussion about such divergences. Huang (1998) argues, through case studies of several Korean Chaebols, that during the catching-up process firms do respond to the same external challenges (governmental policies, market structures and technological changes, etc.) with different strategies. The difference is deeply rooted in their organisations so that she adopts the term “rigidity” from Leonard-Barton (1992). Figueiredo (2001) criticises Kim (1997)’s study for taking the successful adaptation of firms for granted only if the external environment works effectively. Certainly, what Kim presents are only the successful cases in Korea. However, he also suggests, “*successful technological learning requires an effective national innovation system to force firms to expedite that learning”* (Kim 1997, p219) and gives more significance to the external conditions than to the in-house learning processes. Hobday (2003, p307), although he stresses the divergences at country, region and sector level, postulates that observed divergences are determined by the initial starting conditions, the timing of entry and the nature and extent of international opportunity open to latecomer countries. Little stress on the in-house efforts and on the organisational and institutional process is made by the above scholars in interpreting the divergences. By contrast, Figueiredo insists that even within the same industry firms could respond differently to the same government policy and follow different technological capability building pathways associated with different learning processes and different performances (Figueiredo, 2001, p15). In Figueiredo’s empirical studies of two Brazilian steel-making firms, he argues some key features of the learning processes (i.e. the external and internal knowledge-acquisition, the knowledge-socialisation and the knowledge-codification) of these two firms differed over time. These differences are associated with the difference of the performances of learning firms, including the rate, the consistency over time and the trajectory of technological capability building. Therefore, it is the in-house learning processes rather than the external factors that determine significantly the inter-firm difference in paths of technological capability accumulation (Figueiredo, 2001). Ariffin and Bell (1999) also demonstrate uneven trajectories, paces and strategies among foreign-invested Malaysian firms, and their dissimilar linkage to foreign parent firms.

Before the research listed above, there were also some scholars who recognised the importance of organisation, namely the carrier of technological learning, as the factor leading to learning divergence. However, they take the organisation to be a factor intimately influenced by exogenous events (Fransman, 1984, p9-p10). However, in his explanation, market competition, which Fransman stresses as a set of external events, would not inherently lead to appropriate ways of learning. Otherwise, the market-oriented reform would automatically lead to technological catching up (but this has not been witnessed in the experiences of Asian Tigers or especially in the case of Korea). Nevertheless, our question is, if we assume that external events could influence firms in searching for appropriate ways of learning, then where does the knowledge about methods of technological learning comes from? We cannot assume that the knowledge about methods has already existed in the circumstances of DCs, or that the learning firms obtain the relevant knowledge through unconstrained trial and error, neither of which coincides with the empirically documented experiences of DCs, particularly considering those countries still far away from successful or potential catching-up.

However, for many studies about technological learning in DCs, particularly for those at firm-level, the organisations of firms are broadly taken as given facts. This partly explains why these empirical studies at firm-level are regarded as contingent. The logics provided by these empirical studies as explanations for the successful/unsuccessful experiences of learning depend on many special settings embedded in the given organisations and in the particular contextual circumstances. Therefore, in these explanations, all of the invisible factors, including the original organisational settings, are taken as exogenous or independent factors affecting the learning process. Thereby, we lack knowledge about where the organisations of learning firms come from, and about how they mobilise their resources and employees to implement learning strategies. In other words, the emerging, building and evolution of organisations have not been included as the centre of learning practices.

The last but not the least point for our re-consideration is that these bottom-up stage-wise models often mix up the discussion of technological maturity and the discussion of relevant capability-building. Usually, the technological maturity is embodied as the artefacts that firms produce and the methods they implement. For example, the acquisition of assembly technologies, the implementation of product engineering or product design, and the R&D activities are categorised into different stages that represent different levels of capability-building. Alternatively, the achievements representing as providing the manufacturing service, providing the design service and doing the self-owned design are regarded as the series of steps on the ladder of capability- building. Bell and Pavitt (1993) highlight the difference between production capacity and technological capability. It reminds us an issue further related to the debate against neo-classical growth theory that the innovation or knowledge creation could not be regarded as free good or by-product of production, unless the logic is built up to couple the activities with the specific knowledge creation.

Therefore, we must distinguish carefully the products, technologies, organisation and relevant capability-building which are included in our case studies. As implied by Pavitt (1998, p441), when discussing about the technological discontinuities, analysts usually treat them instead with the product discontinuities. It is similar that in describing the upgrading of capability-building, what analysts present are usually the discontinuities of products of learning firms. Therefore, "*greater care and attention needs to be devoted to the distinctions between the artefacts (products, etc.) that the firm develops and produces, the firm-specific technological knowledge that underlies its ability to do so, and the organisational forms and procedures that it uses to transform one into the other* (Pavitt, 1998, p434)". If we do not make clear distinction among these concepts, below can be an example question to ask: does making use of the mature technologies or doing the product assembly absolutely means low-level capability-building? For example, as regards the most mature part of nanotechnology or VLSI (Very Large Scale Integrated) circuit technology (artefacts dimension), it is still difficult for a starting-up latecomer firms to start their capability-building with (technology/knowledge dimension), unless there have already been knowledge or knowledge creation mechanism in their organisation or contexts they can mobile (organisation dimension). Similarly, the capability for product development is generally regarded to belong to a medium or even higher level capability stage, referring to the ladders of Kim (1997) and Lall (1992). Nevertheless, can we compare the capability of designing comparative low-end product and the capability of manufacturing existing frontier products? If not, should the capability for developing products in-house be developed definitely after the completion or maturity of capability-building for manufacturing?

In fact, even in the early stage that latecomers make use of the existing foreign technologies, the role of in-house technological learning cannot be peripheralised in order to undertake effective capability-building. Bell and Pavitt (1995) point out that even in the later stages of the product life cycle there is often little technological stability. Gomory (1992) also describes the later stages as the "cyclic process", which embodies with repeated, continuous, incremental improvement, by comparison with the "ladder process" based on scientific knowledge in the early stage. In the "cyclic process", the competitiveness of firms cannot be merely attributed to their manufacturing operations; rather it is based on cooperation between design and manufacturing. Therefore, we cannot assume that it is unnecessary for latecomer firms, which are making use of mature foreign technologies, to develop their own capabilities for generating and managing technical change. "*Consequently, DC firms in supposedly mature industries may need to develop substantial capabilities for generating change in order to achieve or sustain competitiveness…Developing these capabilities requires constantly improving techniques through actively engineered technical and organisational change, not just the kind of passive "learning by doing" that yields increased proficiency in operating given techniques as a result of increased production experience* (Bell and Pavitt, 1995, p78-79)"

The fact that latecomer firms grow their capabilities through relevant technological development activities is not our point to argue. Rather, we stress that, we must bring up the correct casual relations between the capability-building processes with the activities implemented, the technologies employed and the organisational systems that carry out learning. Considering that, latecomer firms should be regarded as platforms of "product/activities – technology/knowledge -- organisation". Our central question here is by what activities (product producing, R&D, or other activities), by what means (technology or knowledge obtained) and by whom (organisation), what capabilities are built? For this purpose, our empirical studies should trace the growth of capabilities based on the "product – technology – organisation" platform rather than only depicting the trajectory of product or activities change. Otherwise, a typical example question could be asked as whether the capability of the higher stage (such as designing product) could be brought up simply by the activities that belong to a lower stage (such as assembling product).

To generate a summary here, behind the question about divergences of technological learning is the question of the effectiveness of learning, which should be presented by clear analyses based on the "product – technology -- organisation" platform. Regarding the bottom-up stage-wise models, as relevant scholars construct technological learning in discrete stages, and require 'jumps' of objectives when upgrading their capabilities from one stage to a higher one, the capability-building should be studied at the real locus that relevant technological learning occurs continuously to make sure that the corresponding knowledge is generated as we argue. This is the fundamental method to promote the generality of our theories. Organisation should be taken as a key objective of observation in the process of learning.

2.2.3 Knowledge accumulation

Generally speaking, knowledge is the instrument to produce further new knowledge, and also the measure of capability-building. Knowledge is also a good agent to connect the product, technology and organisation in theory into an integrative platform.

DC firms are short of two kinds of knowledge: the knowledge for producing complex products or services, which should be regarded as for the capability-building in a static sense, and the knowledge as guidance for learning itself, which should be regarded as for the organisational capability building in a dynamic sense.

2.2.3.1 Knowledge as objects of learning

Learning in its essence is definitely carried out by individuals. As Simon (1996) points out, organisations learn in only two ways: through the learning of their members or by ingesting new members who have knowledge the organisation has not previously had. However, in practicality, the learning of individuals must obey the boundary of organisational institutions. As Simon (1991, p125) points out that what an individual learns in an organisation is very much dependent on what is already known to (or believed by) other members of the organisation and dependent on what kinds of information are present in the organisational environment. On the other hand, learning leads to both the development of insights and the restructuring of organisational problems (Simon, 1969). Technically, individuals learn together through interactions and share the process with each other, which leads to the argument that organisational learning is not the cumulative result of the individual learning of its members (Hedberg, 1981, p6). Furthermore, particularly in a catching-up firm with articulated common developmental goals, individual learning must be organised according to organisational arrangements for catching-up purposes. That is to say, issues related to what kinds of problems are to be dealt with[4] by using what kinds of methods, who are arranged to confront with these problems and on what support they can rely are closely connected to the organisational settings. Therefore, organisational learning is directed by the corresponding institutional arrangements. The gap of theoretical development between the individual learning and the organisational learning in literature is recognised by some researchers when they carry out studies in DCs. For instance, Dutrénit (2000, p39) points out "*the literature on innovation has approached learning mechanisms at the firm-level without taking into account the extent to which and by what means individual learning is converted into organisational learning.*" We still have not grasped the full picture of the process of knowledge creation in the empirical studies of latecomer firms if we consider it as an organisational process in addition to individual learning.

For some empirical studies about technological learning in DCs, and particularly for some early literature, the process of knowledge creation is not placed at the centre of study. Researchers take the process of knowledge creation as implicit when they discuss the trajectories or the "what" question of knowledge creation (Enos, 1982, 1991). "Learning by doing", initiated by Arrow (1962) through his study on the U.S. aircraft industry before and during World War II, is broadly adopted in relevant conventional literature to interpret incremental technological progress. This

[4] According to Argyris and Schön (1978), organisational learning involves the detection and correction of error.

concept is also implicitly adopted by relevant literature, which leads to a series of discoveries in studying technological progress within industries, such as Rosenberg (1969), David (1975) and Silverberg et al (1988). Considering the reality that DCs usually do not have strong scientific foundation during their period of industrialisation, "learning by doing" is generally emphasized by scholars, by comparison with the STI mode of innovation (Lundvall, 2007), namely learning based on promoting R&D, utilising and creating access to explicit codified knowledge.

However, the effects and the mechanisms of "learning by doing" should be cautiously treated. Bell, Scott-Kemmis et al. (Bell, Scott-Kemmis and Satyarakwit, 1982; Scott-Kemmis and Bell, 1986) argue that "learning by doing" usually comes to be seen as a kind of costless by-product of production activity, since the followers of this concept often simplify its relevant qualification conditions. For example, Hartley (1965) takes the learning (efficiencies) as the linear effects of activity repeated by practitioners[5]. Through a series of surveys on a steel plant in Thailand, as well as the studies of airframe and shipbuilding industries during World War II, Bell, Scott-Kemmis and their colleague stress that "learning by doing" in its narrow sense cannot explain the productivity development curves for infant industries. Namely, neither the improvements of productivity in DCs (their paper in 1982) nor those under a broader circumstance (their paper in 1986) actually simply follow the growth of experience at all, or at least the causal relationship is not significant. Therefore, Bell and his colleagues and other researchers (such as Dahlman, Ross-Lason and Westphal, 1987) emphasise that technological learning is a purposive process that requires conscious efforts and explicit resource allocation. This has been advocated by many scholars in recent decades, such as Lall (1987, p1), Malerba (1992), Fagerberg (1994) and UNIDO (2002).

Since the purpose of technological learning for firms in DCs is to catch up with frontier firms or to shorten the capability gap between them and the firms in developed countries, the knowledge new to their previous possession that was generated through activities they previously undertook is important. The learning mechanisms, including "learning by searching", "learning by hiring" and "learning by training", are stressed by Bell (1984). These thoughts include the features and mechanisms buttressed by Bell and his colleagues, which are summarized with the term 'dynamic learning' (Hobday, 2007). For example, Dahlman and Westphal (1983), Westphal, Kim and Dahlman (1985), and Amsden (2001) highlight the process of importing technologies as an influential source of knowledge; Bell, Ross-Larson and Westphal (1984) underline "learning by hiring"; Scott-Kemmis (1988) emphasises the training, collaborative knowledge development and openness to external knowledge and so on that are important for knowledge acquisition. Enos and Park (1988) also highlight the external training. They elaborate the different stages of technology

[5] It is quoted from Scott-Kemmis and Bell (1986, p5)

importation among Korean industrial firms as organised by Korean government, and demonstrate the process of knowledge acquisition undertaken by Korean firms through technological transfer from advanced countries. Malerba (1992) points out that the specific directions of incremental technical change are closely related to specific types of learning processes. Ariffin and Bell (1999) stress the external training and different kinds of 'learning by doing'.

However, even acknowledging the purposive and resource-intensive features of technological learning activities, the process of knowledge creation is still overlooked in many case studies when scholars discuss knowledge-conversion, products upgrading, etc. Some still take the R&D expenditures or the labour hours invested as the centre of studies; this is the same in essence as Arrow's conversion from the time or investment that learners expend on effective experience accumulation. They pay insufficient attention to the conditions of knowledge conversion from the "measure" of learning they adopt to the real learning effects they speculate. Others neglect the "what" question while they stress the conversion process. For example, in Kim (1997, 1999)'s empirical studies, he uses an integrative model based on the spiral SECI (Socialization – Externalization – Combination - Internalization) model of Nonaka and Takeuchi (1995) to explain the knowledge creation process of Korean firms. However, Kim has not explored from where the original knowledge sources are accessed, or he has not explained the process of learners about the recognition and selection of knowledge source, i.e. the question of "what to learn". In analysing the shift of these firms from one stage to a higher stage, Kim introduces mainly the "absorptive capacity" and "constructed crisis" to explain the capability growth of firms (Kim, 1995, 1997, 1998). Without doubt, the hardworking spirits, the in-house tacit knowledge base and the resources invested in learning are important for generating new knowledge; and crisis construction could be well understood as a method to mobilise organisational members for new learning. However, Kim seldom mentions what kinds of activities, and based on what institutions of resource allocation, specifically corresponding to the target of learning, are carried out to generate the new knowledge that is able to push the learning firms developing onto a higher stage. In other words, the question about what knowledge can be obtained by individuals through their activities of SECI process should be studied as equally important with the study of relevant knowledge conversion process.

As for the "what" question, as some scholars indicate, outcomes of organisational learning may be negative (such as Dodgson, 1993, p377). As for the 'how' question, the research of Dutrénit (2000) implies that the SECI process needs deliberate organisational coordination; otherwise, there can be lack of effective mechanism for the codification process. That is to say, the "myopia of learning" should be considered (Levinthal and March, 1993), which indeed is connected to our concern of "effectiveness" of learning.

To discuss the "what" question and "how" question in a more concrete way, if we take the "water" as a metaphor of "knowledge" and "looking for water" as "technological learning", then the technological learning of DC firms at early stage of catching-up can be compared as a community looking for water in a desert. Only having efforts (hardworking commitments and practices), resources invested and slogan for mobilising people are not sufficient, which does not mean they are not important. People would still need to know what water they should look for (i.e. water from underground, water from air, water from "hydrogen+oxygen" chemistry process or water from a pipe/canal), and how to get the water (i.e. how to carry out the construction project to dig a well/canal, how to collect the water from air, how to generate and supply energy to realise the physical-chemical "hydrogen+oxygen" process). Only with the right questions are put into the discussion held by the corresponding organisation, could output the right answers. Continuing digging sand, although it could be associated with heavy resource investment or great efforts, is not guaranteed with success of finding water.

Therefore, if we adopt the SECI process in explaining the knowledge conversion process, we must provide sufficient analysis on the search of knowledge and the knowledge creation based on a "product - technology - organisation" platform. Otherwise, the mainstream activities in previous stages in bottom-up stage-wise theoretical ladders do not support the interpretation of new knowledge acquisition and conversion for capability-building in a later stages.

Dutrénit (2000) also adopts the SECI model for elaborating the process of knowledge acquisition and conversion. Possibly acknowledging such a weakness above, she terms the development process across stages the "transition process", and argues that there is no simple linear progression along capability-building. Dutrénit pays her major attention to the external sources of knowledge and the conversion process within the uneven organisational structure.

Furthermore, as for the deliberate search of knowledge, namely the mechanisms of learning from hiring, learning from personal training, etc., we do agree that those mechanisms are important. However, it should be noticed that in literature the knowledge-obtaining process is usually measured by the investments made in relevant projects, such as the time, human resources, finances invested. These measurements can provide *ex post facto* tests of whether their choices -- the knowledge sources and patterns of knowledge creation -- are effective. However, the implication should not be treated as that successful learning happens just as decision-makers of learning firms do the right decisions to carry out the right projects, and to make the right resource investment. The explanation of this kind would be difficult to generate any *ex ante* or non-contingent implications about learning effectiveness.

Regarding the effectiveness of technological learning, some scholars discuss this topic from other perspectives. Using the global value chain approach, scholars study how non-core members capture key competences of the whole chain (Kishimoto, 2004; Schmitz, 2007). Additionally, in the global production system approach, scholars focus on how network flagships transfer both explicit and tacit knowledge to local suppliers through formal and informal mechanisms (Ernst and Kim, 2002; Ernst, 2005, 2007). However, without in-depth investigation of the firms, readers would still be confused regarding which firms in DCs could be the “lucky ones” in comparison to other local counterparts. Readers would also be confused as regards whether it is the shift of these global value chains or the emergence of local innovative capability that primarily drives this change.

Besides, the literature about knowledge management of frontier firms, such as those that consider “learning by using” (Rosenberg, 1982), “learning through R&D” (Cohen and Levinthal, 1989), “learning from customers and through the cooperation with rivals” (von Hippel, 1988), “learning via user-producer interaction” (Lundvall, 1985, 1988, 2007), “learning through strategic alliances” (Hagedoorn and Schakenraad, 1994) etc., certainly can provide insights. Malerba (1992) and von Tunzelmann and Wang (2007) have generated a summary, presented in the following table (Table 2.1). However, the summary has not been tested for its validity by detailed empirical studies in the context of DCs. For example, in Lundvall’s research, he stresses the “user-producer interaction” as the micro-foundation of technological learning (and the concept of national system of innovation). However, what he emphasizes is the early users and early producers (competitors). Then, how shall we consider the situation in the national innovation systems of DCs? Can DC firms generate important knowledge or develop innovation through their interaction with local customers who would not be regarded as the early users in the global contexts? How can DC firms balance, assimilate, and integrate the knowledge from foreign source, the knowledge from market through reverse-engineering and the knowledge from interaction with customers?

Thus, questions still exist regarding how DC firms, as the latecomers in the global modern industrial community, can recognise appropriate patterns of learning and enable their organisations to be effective, in view of their deficiency of relevant knowledge or prior experience.

Table 2.1 Taxonomy of Learning Mechanisms

Source	Internal	External
From production	Learning by doing	Learning by spillover
From consumption	Learning by using	Learning by interacting
From ‘search’ (supply)	Learning by training/R&D	Learning by education/S&T

Source: von Tunzelmann and Wang (2007, p201), also see Malerba (1992)

2.2.3.2 Knowledge as guidance for learning

Following the above discussion, in DCs, technological catching-up in a particular industry is always some experience new to the relevant practitioners. Entrepreneurs, managers and engineers do have not experience before they really carry out the corresponding activities. Apparently, repetition of the low-stage activities or routine operations cannot bring out significant new knowledge to support firms grow fast toward a new stage. As Cohen and Levinthal (1990, p149-150) point out, by their statement about the absorptive capacity, "…*absorptive capacity is more likely to be developed and maintained as a by-product of routine activity when the knowledge domain that the firm wishes to exploit is closely related to its current knowledge base. When, however, a firm wishes to acquire and use knowledge that is unrelated to its ongoing activity, then the firm must dedicate effort exclusively to creating absorptive capacity (i.e., absorptive capacity is not a by-product).*" As the absorptive capacity for knowledge in new domains is not an automatic by-product of the ongoing activity, the learning firms must build up their understanding about what to learn and how to learn.

In fact, even only considering general tactics, latecomers also have to explore their own paths and patterns under the external equivocality. It is because they do not ever have corresponding experience, and they very possibly may face different external contexts by comparison with their forerunners did (Gerschenkron, 1962). Therefore, the cognition about what to learn and how to learn lies in exact the heart of successful catching-up. Take the trade-off between technological importing and local technological accumulation as an example. Q. Lu and Lazonick (2001, p73) and Bell and Pavitt (1993, p193) both take the complementarity between technological importing and indigenous innovation as a central concern of industrial development in DCs, and describe it as a balance that must be dealt with deliberately. In other words, it is a question of cognition about the developmental trajectory relevant to the contexts of learning subjects. Similar questions could be asked at more micro levels for all kinds of trade-offs about learning. Langlois (1997) presents exactly such a historical study of the computer industry in United States, in which the organisational perception and market perception matter much in developing the learning trajectory of firms. Since the answers to these questions reside in-depth in the complex economic configurations of learners, the cognition should be regarded as one kind of intrinsic knowledge developed in a learning process, other than something just simply obtained from any textbook or other external sources.

Thereby, at least two assumptions should not be taken for granted in our study. First is the assumption about perfect effectiveness of organisations regarding technological learning, including the perfect efficiency of learning itself and the perfect efficiency of organisational change in order to implement proposed learning activities. Second is the assumption that the organisation of DC firms is ready and set up properly for the proposed learning activities. DC firms are not situated in an atmosphere full of knowledge that is precisely needed, although they are very likely in an atmosphere full of information (about learning patterns) advocated by all kinds of forces (such as the advocacy of *Washington Consensus*, etc.). There is no practical blueprint for building a learning organisation (Pedler, Boydell and Burgoyne, 1989, p4). For the complexity of organising technological catching-up during a long process and under the global competition circumstance, relevant knowledge about learning pattern itself is very difficult to gain through technological transfer or copying other's strategy. Organising, which is the mechanism to reduce the number of potential interpretations for the equivocality of environment (Weick, 1979), is the only way to decipher and develop the complexity of knowledge. In Kogut and Zander (1992, p390-391)'s discussion, they stress by a metaphor of computer hardware and software technology that being taught technology (employing software) is separated from being able to create capability (understanding hardware and to create software). The translation from understanding hardware to exploiting its functions by using software means, through the process of codification, the needs of substantive technologies are reduced to some extent. During such a "learning to organise" process, the organisational hierarchy plays critical role by steering the direction (Gavetti, 2005). In contrast with the abstracted information that is imported from external sources, the tacit knowledge at multi-dimensions that is held and developed by learners is the core of such a process (Nightingale, 1998). Therefore, our arguments lead to Rosenberg's (1976) opinion that reliance on borrowed technology (by DCs) perpetuates a posture of dependency and passivity, other than fast- development.

The above discussions are also suitable for the effective learning patterns of DC firms. During the dynamic process to shorten the gap with advanced country firms, DC firms shall accumulate new knowledge continuously. Therefore, to develop their own cognition for guiding their own learning, and to solidify the cognition by institutionalised organisational arrangements, are necessities and non-stopping tasks for them during their journey of catching-up – whether such tasks could be completed intentionally or unintentionally. Simply borrowing learning strategies or organisational designs, if lacking substantive social conditions to support, is barely enough to ensure the capability to generate the "new-new" knowledge dynamically according to its evolving environment.

That is to say, we shall anchor our investigation from the cognition development, the trajectory adoption, and the organisational construction or transformation of DC firms, rather than only starting from the learning behaviours based on well-set organisational frameworks.

At the firm level, cognition is regarded as an important factor in the studies of technical innovation. Gavetti and his colleagues (Gavetti and Levinthal, 2000; Tripsas and Gavetti, 2000) stress the cognition of firms in understanding inconsistent changes of technology and organisation. The cognitive development is based on historical experience (Kiesler and Sproull, 1982), and there are dynamical connections of cognitive development between individual firms and the social shared realities (Garud and Rappa, 1994).

Other scholars also employ different but relevant concepts to interpret corresponding influences on the firm's technological learning. Moorman and Miner (1996) suggest that the patterns by which organisations deal with incoming information is influenced by their memory, so that the process of product development is impacted. Higher-level learning[6] is also worth noting, which is close connected to the non-routine change. The upper level learning engenders the development of differentiated structures, rules, and so on. Furthermore, it also generates insights, heuristics, and collective consciousness (Fiol and Lyles, 1985). For the DC firms, especially those in their early phases, there must be an evolutionary process through which decision-makers accumulate knowledge and build their organisational learning system. During this process, the organisational structure, rules, norms, and so on, work as the platform for technological learning for the whole organisation, which certainly influence the learning at a lower level, directing what organisation members should learn and how they should learn.

The cognitive development certainly is based on the memory of organisation or decision-makers in early stages. Experiences owned by firms define the locus of their searching for knowledge generating (Rosenkopf and Nerkar, 2001). Generally, experience reflects an organisation's successes and failures over time (Nelson and Winter, 1982). They are generated through practical operations of firms, namely learning by doing, learning by using, learning by interacting, as discussed previously. Besides, experience can also be obtained through environmental scanning including learning from competitors (Fahey, 1999), through benchmarking (Garvin, 1993), and so on. Specific to DC firms, they are deficient in relevant experience for high stage capability-building. Therefore, the governmental policy, relevant value network, information about learning generated by close customers and partners, the backgrounds of high-level organisational members, the experiences in their initial phase when they transfer into a new stage (Feng and Zhang, 2007; Kaplan, 2008) may influence the development of latecomer firms' cognition about learning.

On the other hand, the cognitive development also presents its intrinsic inertia. Once formed, the cognitive frame tends to resistance against changes (Walsh, 1995), especially if we consider it with a connection to the trajectory adoption and organisational construction or transformation. As pointed out by Tyre and Hauptman (1992, p302), using the new technology may also bring about the systemic shift in production approaches and underlying organizing principles. Normann (1971) points out that considering the tasks and knowledge changes caused by innovations to internal subsystems, groups involved in interdepartmental projects must develop and adopt a new set of organisational relationships and communication structure. Then in case study of technological

[6] It is in comparison to the lower-level learning that is defined as to dealing with routine change under the existing rules, institutions and norms. It could also be referred to Argyris and Schön (1978).

learning of latecomers, their cognition about learning is something to develop and exploit with either institutionalised organisational setting, or can be something to adjust with organisational reform for strategic shift.

In addition to the cognition of patterns for technological learning, absorptive capacity is another well-known concept involved with knowledge accumulation that can direct the further knowledge generating of latecomer firms. Absorptive capacity refers to the acquisition or assimilation of information by an organisation and also the organisational ability to exploit relevant information (Cohen and Levinthal, 1989). This concept is rooted in the research of relation between the memory with the facility of knowledge acquisition (Bower and Hilgard, 1981), concerning a central question of "learning to learn" (Ellis, 1965; Estes, 1970)[7]. Primarily, absorptive capacity is defined by Cohen and Levinthal (1990, p149) as a part of a firm's calculus in allocating resources for innovative activity. In doing so, Cohen and Levinthal stress the structure of communication between the external environment and the organisation, the communication among different subunits of the organisation, and also the distribution of expertise and its role in the organisation.

However, when absorptive capacity is to be measured, R&D intensity is adopted as the input (Cohen and Levinthal, 1990). In fact, on discussing absorptive capacity, especially considering the capability-building of latecomer firms in DCs, it is quite frequently measured or even indirectly defined by the resources invested in technological development and management activities. Mowery and Oxley (1995) measure it at country level by the investment in S&T (Science and Technology) training and governmental policies supporting the industrial competition. Also at country level, Keller (1996) measures the absorptive capacity by the density of engineering students, scientists and engineers, scientists and engineers in R&D in different subset of population. X. Liu and White (1997) define it as the investments in R&D personnel. Kim (1995, 1997) measures the absorptive capacity by the existing knowledge base especially existing knowledge tacit base, and the intensity of effort or commitment. Regarding the first element, because the knowledge in question is tacit, the analysis has to be based on narrative description. As to the intensity of efforts, Kim in fact employs the hardworking spirit and tradition, resources invested and crisis construction to describe the commitments. At the firm level, Boynton, Zmud and Jacobs (1994) explain this concept by the managerial IT knowledge (actually the investment in managerial IT knowledge). Veugelers (1997) measures it by the internal R&D expenditure, governmental sponsored R&D, and so on.

As implied by Cohen and Levinthal, the capability of absorption shall be considered not only by the quantity of resources (and human force) invested in in-house R&D, but also rest on the

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[7] It is quoted from Cohen and Levinthal (1990, p130).

communication mechanism and expertise system --- in my view, it is also connected to the power distribution. By such a concept, in addition to influence by the efforts and the previous knowledge base at the individual level, technological learning is directed by the internal political distribution. As well, the learning performance is determined by the resource allocation and the structure of existing knowledge distribution -- as the platform to process learning. All these factors, many of which are related to the organisation dimension, should be considered systemically rather than being measured merely by resources invested. However, for practical application of this concept, the limitation of these measurements that we elaborate above and are based on resources (finance, human force and time) invested mainly, constrains this concept from incorporating the analysis of the patterns that resources are utilised, and the patterns that prior knowledge enhances the exploitation of relevant new knowledge by firms. Moreover, such a limitation can likely bring about misunderstanding for readers that there is a linear model between the R&D investment and absorptive capacity, and then the performance of technological learning. Therefore, we comment that the concept of absorptive capacity has a significant theoretical background, but has not so good practical application, which in fact turns it to the RBV. Indeed, the pattern of simply utilising previous in-house R&D to analyse absorptive capacity or innovative capability has been doubted. For example, Gomory (1992, p393) argues with his prolific industrial practical experiences that it is the industrial success which causes the R&D spending, not the other way around.

Zahra and George (2002) extend the concept of absorptive capacity, and develop a heuristics by defining the "potential absorptive capacity" and "realised absorptive capacity", including acquisition, assimilation (for the potential part), transformation and exploitation (for the realised part) segments. They take the social integration as the critical mechanism to bridge the potential absorptive capacity and realised absorptive capacity, which do echo the primarily concept construction of Cohen and Levinthal (1989, 1990) and generate an important implication for studying the performance divergence among latecomer firms within the same national innovation systems. However, we still have to solidify the theoretical framework with comprehensive empirical studies, such as Lazonick does for a similar concept at the country level (Lazonick, 1990).

2.2.4 Organisation and technological learning in DCs

The relation between the organisation and the technological learning has been well explored by scholars involved in the study of organisational learning from varied domains of academy, such as Argyris and Schön (1978), Hedberg (1981), Fiol and Lyles (1985), Senge (1990), Kogut and Zander (1992), Dodgson (1993), and so on. The relevant literature provides us many insights related to our study here. For example, technological learning has its own trajectory (Dosi, 1982), but also has path-dependency (David, 1985; Dosi, 1988) which means the firm's possible choices of learning depends on its accumulated competences (Pavitt, 1991). Conflicts exist between the technological exploitation and technological exploration, according to the organisational intent to refine and extend the existing competences, technologies and paradigms, or to developed new alternatives (March, 1991).

However, as in the literature about the technological learning of DC firms, only a few scholars have placed the relationship between organisation and knowledge accumulation as their central topics. Tiralap (1990) studies the electronics industry in Thailand, and discovers that the perceptions of owners or managers regarding the effect of technological change on business growth, as well as their perceptions about the effect of workers' skills on technological change, and how both play a positive role in technical and business performance. Studying a small learning firm in the welding market, Jamaica, Girvan and Marcelle (1990) stress the perceptions of entrepreneurship and management are important in realising "active technology acquisition" through overseas training, foreign technical assistance and so on. Tremblay (1994) studies the firms based on the Likert framework (Likert and Gibson-Likert, 1976), including namely the type of hierarchy, supportive relationship, motivation, decision-making, control, channel of communication, information flow, interaction-influence, organisational slack, and management attitude regarding human resources development. By comparing the pulp and paper industry in Canada and India, Tremblay points out strong positive relationships between productivities and resources committed to "improvement-type" technical change. Even though Tremblay also studies the resources committed to "improvement-type" projects that are not recorded as capital expenditure, his research is based on a survey and on an improved version of Likert framework. Not enough attention has been paid to the causal relation between the organisational dimension and technological learning performance. Additionally, what he compares are firms in industrialised country with firms in industrialising country, which represents an obvious contribution to the academic community's understanding of the issue. However, considering the complicated industrial circumstances at work in different countries, especially countries in different phases of industrialisation, it is still a bit difficult to develop a true understanding of the dynamics of DC firms' learning, or to identify the dynamics of the diversification of firms in DCs.

Dutrénit (2000) also stresses the role of organisation structure in technological learning in her research of DC firms' acquisition of knowledge from external sources. She studies the unevenness of knowledge accumulation in different parts of organisations. On the centre stage of her study is a couple of technological unevenness and organisational unevenness. Knowledge sharing and codifying are her major concerns when discussing the couple of unevenness. Coordination and integration across organisational boundaries are the focuses of her studying, rather than the organisational (or political) dimension that leads to the particular uneven structure and then the unstable knowledge-creation process. As Dutrénit (2000, p300) herself admits that the unevenness itself may exactly be the consequence of the transition process. In fact, according to my opinion and on the other hand, the discontinuously technological learning, rather than the repetition-based "learning by doing" in narrow sense, is an uneven process in essence, by which the unevenness works as the endogenous source of dynamics for the growth of the system. However, by comparison with Dutrénit's case study, in successful capability-building processes, one kind of unevenness should be compensated by another kind of unevenness to realise the dynamic equilibrium of the system. Therefore, the institutions to compensate or failed to compensate the unevenness should be treated as a crucial part to investigate. As mentioned by Dodgson (1993, p380), the conflict (caused, for example, by error or contrary evidence) is an essential condition for learning, which acts as a motor driving the learning process. Coriat and Dosi (1999) also point out that the routine is not only about coordination and problem-solving but is also a locus of conflict and governance and a way of codifying microeconomic incentives and constraints. Therefore, the evolution of routines is related to how the organisations respond to the conflicts and constraints.

Q. Lu's study (Q. Lu, 2000; Q. Lu and Lazonick, 2001) aims to explore the inside of organisations directly by studying the catching-up efforts of Chinese computer manufacturing firms. Lu adopts and further develops a framework put forth by Lazonick and O'Sullivan (Lazonick 1990, 1991, 2003, 2004; Lazonick and O'Sullivan, 1996), for analysing the institutional conditions that support the innovation processes of firms. Focusing on corporate governance, the framework includes three important questions, taking "resource allocation" as the central issue: (i) who makes investment decisions, (ii) what types of investments are made, and (iii) how returns are distributed. In his case study of four firms in the Chinese computer industry, Q. Lu investigates managerial autonomy, commitment to technological learning and incentive systems in firms that are new to those under the demanding economic system. He explains why a unique top-down mode of technological learning can happen in China is that the firms in question have made progresses on the above three aspects of corporate governance[8] that can make use of the R&D resources accumulated from the central planned age. However, Q. Lu's research does not underline the differences between organisations. If the three conditions were sufficient for effective learning, well-transformed domestic firms should be able to make proper use of the existing accumulated knowledge resources for in-house capability building. However, this supposition is apparently not observable to researchers. Along with the deepening of the economic restructuring, more and more Chinese firms have gradually won management autonomy, made a sufficient financial commitment to innovation, been able to allocate technological resources on

[8] Lu (2000) adopts the definition of corporate governance developed by Lazonick and O'Sullivan, that it is defined as a set of social institutions that influences the strategic allocation of resources and returns in business enterprises, which is different from the conventional definition. We follow this definition of corporate governance in this paper.

their own, and even in some cases been named innovative enterprises for their remarkable inventions, when they still cannot successfully present an effective learning trajectory. Even among the leading firms, learning patterns and the performance remain remarkably divergent. Some innovative firms, including all of the firms Q. Lu examined in his case studies in the 1990s, have met difficulties in terms of continuing technological capability building and transferred themselves to being mainly manufacturing-oriented.

Hence, even though there have been limited literature dedicated to understanding the role of organisation in technological learning of latecomer firms, it is still very demanding to develop further empirical studies on this topic. The central issues should be how the organisations are built and how they influence and interact with technological learning.

2.3 Studies of China’s capability growth at firm and industry levels

Regarding the studies on China’s growth, as the Chinese industrial economy is a large system and China implements a gradualist strategy of reform in the past decades, this creates difficulties for scholars to understand its dynamic changes, especially when some changes are still in their rudimentary stage.

Taking the works of Nolan as representative, he has maintained his interest in Chinese industrial competitiveness in the past two decades (e.g. Nolan, 1996; Nolan and Yeung, 2001a, 2001b). Through comparing some large industrial firms with the giant firms in developed countries, Nolan concluded that the capability gap between Chinese firms and international giant firms had continuously enlarged during these past two decades. He postulates, if confronted with open global competition, Chinese large firms would perish or at best would become the branch plants of globalised big business (Nolan and Wang, 1999). Nolan’s assertion may be right for some of the giant SOEs that he observes. However, Nolan focuses his eyes only on the large industrial SOEs, namely the orthodox stream of China’s reform inherited from the previous central planning system. His neglect of the growing forces outside the orthodox system makes him insensitive to the dynamics caused by newly emerging firms and the social conditions that support such a change. Therefore, it is not difficult to understand his pessimistic and invalid estimation. The bottom-up growth forces, which gradually dominate indigenous technological advance in some industries today, not only have brought new elements into the Chinese industrial system, but also changed the structure of this system.

In their research on changes in global production networks, Ernst and Naughton (2007) reveal different behaviours of Chinese domestic firms during the transition process, and develop a three-tier analytical framework for studying the divergence of Chinese domestic firms. However, as their study focuses on the linkages between the Chinese industrial economy and the continent (such as the greater China) or the global industrial economy, they put the export-oriented industrial section of China in the centre of their research, while overlooking the other growing industrial forces, which is also reflected in Naughton (1997, 2007). Therefore, limited by their perspective, they take the transition of relevant global production networks and the growth of Chinese market demands as the major dynamics of the rise of Chinese technology-oriented firms (Ernst, 2005). When discussing Chinese innovation, many other scholars also centre their research on the spillover of foreign technologies, and make the indigenous innovation peripheral to their study of Chinese technological capability growth (Ho, 1997; Young and Lan 1997). As they have not placed the transitional innovation system of China at the centre of their research, these scholars are quite indifferent to Chinese indigenous innovation, which has been criticised by Q. Lu and Lazonick (2001, p72-73). However, the fact is, at the time of their writing, some important indigenous innovative firms had been emerging, as demonstrated by the work of X. Shen (1999), Q.Lu (2000), F. Lu (2006), etc.

As a large system, the transition of Chinese industrial economy does not only include the changes of internal factors and the external linkages, but also includes the changes of dynamics, internal relations and growth patterns. If taking a horse-cart full of cargo as the metaphor for Chinese reform and growth of the industrial system, the objects changed not only involve the cargo, but also involve the way to transport it: the horse may be replaced with a motor, or by a hybrid power system, i.e. horse and motor. Therefore, it is important to go inside the Chinese industrial system and even the firms, and to identify the emerging forces and relevant changes that possibly cause upgrades of the whole system. In consequence, a longitudinal study of the domestic divergence of industrial development is important to generate a better understanding.

A series of scholars have provided excellent studies of the transition of the Chinese industrial system, such as Naughton (1996), Gu (1996, 1999), X. Liu and White (2001), Lieberthal (1995), etc. Naughton (1996), from the perspective of political transition, demonstrates the detailed process of China's transition during 1978 to 1993 that was exactly the reform period before China's fundamental ownership reformation of SOEs[9]. In her book, Gu (1999) takes the reform within organisations and between them (firms and institutes in particular) to be interactive with the success of market-oriented reform in China since the late 1970s. Organisational change, mainly as related to the budget system and managerial autonomy, is taken as a core issue in the emergence of new knowledge-based firms, both for spin-off firms and for those that were transformed from research institutes. The research of Gu clearly demonstrates a specific period of institutional change as part of China's economic reform. X. Liu and White (2001) adopt a similar perspective; they make a comparative study of Chinese innovation systems along with the

[9] A fundamental reformation of state enterprises was started in 1993, by which the state operated enterprises were changed to state owned enterprises.

institutional reform. The above studies provide important institutional backgrounds for our understanding of technological learning of Chinese domestic firms, and explain the rise of some technology-oriented firms --- especially those spinning off from universities, research institutes and those supported by governmental S&T projects, such as in Gu (1996). They point out the sources of some newly domestic firms to advocate S&T intensive strategies, but have not explored the organisational patterns of technological learning of these new firms in longitudinal research.

However, as regards the mainstream of Chinese policy-making and academic thinking, the theory of comparative advantage and the advocacy of "late development advantage" by borrowing and/or copying existing and mature foreign technology are still prevalent among Chinese scholars in recent decades, especially among those scholars who have close relations with policy-makers. For the sake of brevity, we just enumerate a few representative works of theirs here. Jin (1997) develops his framework based on comparative advantage to study the industrial competitiveness of Chinese domestic firms. Lin (Lin, 2002; Lin, Cai, and Li, 2000) stresses the promotion of factor endowments rather than the emphasis on industrial upgrading and technological exploration. Being backward is treated as the advantage of Chinese development, so that to make use of existing technologies and to focus on large-scale production is taken by them as the sources of Chinese industrial competitiveness and dynamics, rather than investing in technological capability (Lin, 2003). Taking foreign technologies as the primary sources of Chinese domestic technological advances, Jiang and Li (2002) provide an evaluation of FDI in Chinese domestic technological capability building. Their arguments describe well the mainstream idea about development held by many Chinese industrial firms that were supported by the government in the 1980s and the 1990s. However, the indigenous capability growth has not happened automatically for most of these firms along with the upgrading of factor endowments. On the contrary, these scholars cannot interpret the growth of emerging indigenous industrial forces outside the "mainstream" they studied in recent decades, which bring about new patterns of learning and cause changes of the entire domestic industrial community.

Take the automobile industry as an example. The stress on economies of scale in production has deep roots in the policy-making and mainstream academic thinking of China. The work of Maxcy and Silberston (1959) had significant impacts among policy-makers and relevant scholars. The research of Xia et al. (2002) and Z. Zhang (2004), among the contemporary academic works, can represent the orthodox thinking in analysing the technological progress of the Chinese Automobile industry; views which are held by scholars closely relevant to policy-making. They take scale economies as the foundation of technological capability building so that to use existing advanced foreign technologies is regarded as a precondition of long-term development of indigenous capability, which coincides with the advocacy based on "comparative advantage" theory. Such thinking in practice advocates establishing JVs with MNCs. J. Lu (1999) provides a series of case studies about how Chinese local producers learn the processing technologies and the operational management skills from the cooperation with MNCs, and how these firms finally get qualified as component providers for the production localisation of the *Santana* model of Volkswagen vehicles. Xie and Wu (2001) have disclosed the limited spillover effect of foreign technology from establishing Sino-foreign JVs. However, they still suggest that the Chinese supply chain could establish technological capabilities through participating in the global production systems; thereby, it may be a feasible trajectory for Chinese indigenous automobile industry to grow from components into systemic products. However, they have not presented tenable empirical evidence for their advocacy, and they neglect that the core domains of component development also require significant technological capability. We can see, even today when Chinese have already been able to develop systemic car models, that it is still difficult for the domestic community to enter some critical domains of components because the relevant undertaking requires the support of basic scientific research as well as long-term accumulation of engineering skills.

In the face of the prevalent thinking of policy-making, the Chinese neo-Schumpeterian views challenge the prevalent opinions. W. Liu (1992) investigates the technological transfer from Volkswagen to its JV with Shanghai Auto. He argues against the simple deduction based on the "product life cycles" theory that entering the mature phase of an industry would be an appropriate choice for catching up. W. Liu concludes that the technological importers have to do more than acquire the physical facilities and the operational skills. The efforts of domestic firms to acquire technologies through importation, the extent to which they put in place indigenous capability building and the rate of technological change all affect the chances of success of technological importation. However, his study concentrates only on learning about processing technology in Shanghai-Volkswagen in the early phase. The learning of product technologies which was expected to happen subsequently has not been included in his study. F. Lu and Feng (2005) provide a systemic explanation about why relying on Sino-foreign JVs has not brought about significant growth of indigenous technological capability. They find that new indigenous firms, which demonstrate well-recognised effects of technological capability building today, have begun to carry out product development from their very early phase onwards. Only with the strategic intent to develop products and with the full set of developmental activities in-house can new indigenous firms effectively accumulate capability for product development, which represents a striking contrast with Sino-foreign JVs. As for the organisational reasons that generate these differences, we will explore them further in this thesis.

Regarding the telecom-equipment industry, X. Shen (1999) conducts detailed studies on the early years of Shanghai-Bell[10] and the emergence of the *HJD-04* model. However, she has not systemically studied the organisation and institutions related to technological learning when she provides a contingent analysis of two firms. She suggests a two-way model for understanding the strategy of Chinese government in this industry. In this two-way model, there is the initiation of Sino-foreign JVs on the one hand, and the indigenous innovation derived from domestic S&T entrepreneurship on the other hand. X. Shen concludes that the Chinese government bridges the two approaches, and deliberately accelerates the knowledge transfer from MNCs through Sino-foreign JVs to newly emerging indigenous firms. The later research of Mu and K. Lee (2005) on the Chinese telecom-equipment industry heavily depends on the empirical details of X. Shen (1999). Mu and Lee push the opinion of Shen further, even though they are short of direct proof, and argue that the technological diffusion from FDI is crucial to the growth of indigenous capability. As to the significance of direct technological transfer from MNCs or Sino-foreign JVs to new indigenous firms, both X. Shen (1999) and Mu and K. Lee (2005) have presented very limited tenable direct evidence.

Fan (2004) presents a different view from the above authors. By regression analysis and interviews at firm level, Fan finds that the contribution of cooperation with foreign companies is only conditional to the capability-building of new indigenous firms when the new indigenous firms are becoming the leaders of technological advance in domestic community, which coincides with the views of Hu et al. (2005). Fan even finds that differently from the conventional thinking of policy-making, the leading indigenous firms, namely Huawei, ZTE, GDT (Great Dragon Telecom Tech.) and DTT, did begin to invest in technological capability building from an early stage. However, since she has not opened up the black box of organisations, and has not explored the process of knowledge acquisition and the relevant institutional backgrounds, readers cannot know how the capabilities are built and how the domestic divergence emerges through her research. In the work of Zeng and Williamson (2007), they argue that it is the intensive R&D investment of Huawei in potential disruptive technological innovation that brings it successful technological catching-up. It is important for understanding the features of product innovation strategies of Huawei today, since Huawei has already become one of the leading telecom-equipment providers in the world. However, it cannot explain properly how Huawei came to be competitive since only several years before it started investing intensively in some

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[10] Shanghai-Bell was established in 1983 by the Chinese side and the Belgium BTM (Bell Telephone Manufacturing Co.). In 2001, Alcatel had 50% plus 1 unit share and dominated this JV. Thereby, Shanghai-Bell was re-named as the Alcatel-Shanghai- Bell (ASB), and became the production localisation and manufacturing base for Alcatel in China; after 2006, Alcatel merged Lucent. Shanghai-Bell was actually renamed as the Alcatel-Lucent-Shanghai-Bell, acting as the division of Alcatel-Lucent in China. However, in Chinese, it still keeps its reputable name "Shanghai-Bell". On the other hand, it was also a SOE owned by China's central government (50% -1 share), listed by the SASAC. In this thesis, we term it 'Shanghai-Bell' all the time for clarity.

technological fields as described by these two authors, Huawei was still a very small start-up company without any advanced technology and with only 21,000 RMB as the registered capital on hand.

By comparison with the above authors, F. Lu and his colleagues (2006, chapter 4) provide another case of top-down innovation in the Chinese telecom-equipment industry. They argue that, by comparison with the policies grounded on comparative advantage theory, indigenous firms in China can develop technological capability successfully, and the initial market is a necessary locus for innovators to improve their products and accumulate more knowledge for technological development and industrialisation.

As for the manufacturing industries in general, Sun (2002) discovers through an aggregate data analysis of Chinese medium and large sized enterprises that even though imported technologies can bring market success in the domestic market, in-house R&D efforts are the primary source of technological creativity, namely the patents applied for by Chinese industrial firms. Recently, their research based on the Chinese ICT industry (Sun and Du, 2009) reveals that even though the technological linkages with foreign technological sources are important for the innovation performance of domestic firms, nevertheless indigenous firms show higher R&D intensity and more motivation in product innovation. Concentrating on high-tech industries, X. Liu and Buck (2007) discover by a regression data analysis that the contribution of MNCs' R&D activities in China to Chinese indigenous technological progress is conditional. Absorptive capability is claimed to be the crucial factor influencing the effect of foreign technology spillover. However, lacking the exploration of organisations, the absorptive capability is defined only by in-house R&D in their research. Xie and Wu (2003) carry out case studies in the TV set manufacturing industry in China. They attribute the success of capability-building of two domestic firms to a series of external factors, including the linkage with MNCs, the tough competition, the scale and the deregulation of the domestic market and risk-taking entrepreneurship. Again, except in considering entrepreneurship, we do not have explanation from inside the organisation to outline the divergence of domestic firms that head technological capability building. Thus, we are still far from having a real picture about their valuable mechanisms of technological learning.

Following Q. Lu (2000), X. Gao and his colleagues (X. Gao, 2003; X. Gao, P. Zhang and X. Liu, 2007) also develop a top-down model and argue that strong manufacturing capabilities will not necessarily enable local firms to develop innovation capability. They deny the applicability of the "late development advantage" in the case of China, because they reveal a series of failure cases related to learning through technology importation. They stress the following factors as important in their empirical studies of China's TV set manufacturing industry: early timing of implementation of in-house R&D, intensive investment in in-house R&D, a large workforce for research, coordination with research institutes and the choice of particular technology. Organisational conditions, including urgency, confidence and resources in developing proprietary technology, are emphasised.

The case studies conducted by S. Gao and Xu (2001) explore the VCD (Video Compact Disc) and agricultural vehicle sectors. The researchers suggest a new techno-economic paradigm focusing on niche markets that would allow indigenous firms to catch up by combining existing technologies using a variety of different strategies. F. Lu and Mu (2004) also stress the domestic market. They term it a strategic factor for indigenous technological learning in DCs. Moreover, they establish the concept of “learning (gradually) by innovating (products)” that domestic firms in DCs also have the possibility to create a top-down pattern. However, they mainly implement an industrial chain development perspective. In another piece of his research, F. Lu tries to open the black box of organisations for analysing Chinese industrial development. He takes managerial control as the central concept to study the situation of capability-building of Chinese SOEs (F. Lu, 2000), and provides a comprehensive historical study on this topic (F. Lu, 1999). He argues that it is not the property-rights reform but it is the reform of managerial structure and organisational form that leads to the birth of successful reforming SOEs. The reconstruction of social relations within enterprises is a necessary process for the shaping of the effective managerial structure and organisational form. In the case study of BaoSteel[11], F. Lu (2002) applies this framework to explore internal sources of Chinese firms’ capability-building. He attributes BaoSteel’s success to its aspiration levels, the persistence in learning by doing and the close interaction with customers.

However, regarding the studies of Chinese industrial capability building, except for just a few works we mention above, there is still little research to take organisation as the central object of analysis to study the capability-building of Chinese industrial firms.

2.4 Summary

In reference to studying the technological learning and relevant capability-building in DCs, the conventional wisdom has already provided us with rich insights. By providing a wealth of empirical studies, the existing literature presents the readers with a sense of how historically technological catching-up processes have been successfully implemented at country level and industry level, how catching-up firms implement specific learning strategies, and follow specific stepwise bottom-up trajectories, and how they progress upstream from one stage to another. Topics such as technological transfers, external influences, interaction with early users or competitors and interaction with suppliers have been explored.

However, in general, the relevant literature about technological learning in DCs has paid

[11] BaoSteel is the largest steel-maker in China, and one of top-10 in the world.

inadequate attention to the organisational and managerial aspects of the learning process (Dutrénit, 2000, p297), and to the construction of organisations. Many conventional works on technological learning at industrial or firm level begin with given substantial settings of organisations. The knowledge about learning patterns, namely the process that firms undergo to build up organisational systems and supportive institutions in pursuing technological learning, has not been so well cultivated. To be more specific at a micro-level, the resource allocation and the organisational platform for learning of firms are included in this subset, needing to be explored. Only with adequate knowledge in these fields can we understand better how DC firms respond to the environments when they have technological opportunities to exploit, have niche market to explore, or have specific trajectory to pass through.

In fact, in the early phase of this academic area's development, scholars have already noticed the differences between learning activities. Based on the RBV framework initiated by Penrose (1959), Bell (1982) distinguishes two kinds of resources, namely the resources needed to operate existing production systems and the resources needed to change the existing production system. This is in fact developed into their definition of technological capability (Bell and Pavitt, 1993, p159), and can be regarded as a predecessor of their distinction between "production capacity" and "technological capability" (Bell and Pavitt, 1993). It provides a theoretical source for thinking about the organisational process to respond to or predominate over the passive or active changes. However, possibly attached to the RBV framework, relevant scholars have not gone deeper into the differences between organisations; instead, they focus more on resource-based projects and investment capability. Their stage models are mainly based on the analysis of successful stories of investment and learning projects, rather than based on the analysis of continuous knowledge accumulation associated with organisational evolution.

If we stress only the investment, pathway-choosing and trajectory-taking of resources, it cannot help us substantially to study the ubiquitous divergence of technological learning of DC firms at all kinds of levels. As mentioned by some researchers, the same strategy or policy may lead to different performances of firms or industries in different circumstances. According to the empirical studies of China, it seems that in many cases the Chinese government and entrepreneurs are aware of the pathways, trajectories and "*late development advantages*", particularly when they aim to follow bottom-up patterns, as our study of the Group-A firms will demonstrate. Or at least they think they are aware of the relevant knowledge. They also know different tactics of knowledge acquisition, namely to train personnel with the aid of external expertise, to import technologies as assistance for in-house capability building, etc. However, the point is whether they are able to mobilise their organisational members and build up effective organisational systems to achieve their strategies. More enterprises fail at technological learning than are successful in the several industries we study empirically, for many of which defeat obviously comes not because firms have not adopted one particular trajectory or make one particular investment. The knowing-doing gap (Pfeffer and Sutton, 2000) between "*knowing the strategy*" and "*realising the strategy*" works, with a series of organisational questions located there.

Turning back to the theoretical consideration, we cannot presume that relevant knowledge about effective learning has existed or has been obtained generally by firms in DCs. Very distinctly, the lack of social technologies[12] in DCs is as important as the absence of physical technologies in leading to their backward status. Thereby, more than just considering the successful or failed cases, our study will go beyond the implementation of technological learning, and explore the evolution of the organisations, including their recognition of appropriate learning patterns, the translation into organisational building, and the resource allocation and application, as well as the knowledge accumulation process based on such the organisational systems. This does not mean we neglect the impact of strategy and project implementation on the underlying organisational settings, such as through the double-loop learning and deutero-learning mentioned by Argyris and Schön (1978) and Argyris (1976, 2005), or the valid learning process put forth by March, Sproull and Tamuz (1991).

In sum, the organisational learning systems of DC firms and the mechanisms they work with to support technological learning are the focuses of our study in this thesis. The target is to deepen our understanding of their catching-up, and identify the source of their divergences. Certainly, this thesis is not able to cover all relevant questions. We cannot even answer all the questions we address in this chapter. To build up an organisational theory for understanding the technological learning process of DC firms, more research is needed to erect a systemic explanation. After all, this thesis has been developed as an initial attempt on part of the author. Through the empirical studies of the Chinese car-making sector and telecom-equipment sector, we primarily aim to point out the basic framework of an organisational learning system, and its significant role in directing and facilitating or obstructing technological learning.

In the next chapter, we discuss the research design. A basic theoretical framework will be developed, which will be the foundation of our empirical study in later chapters.

[12] It is a term from Nelson (Nelson and Sampat, 2001; Nelson, 2008), which is also put forth by North and Wallis (1994), Boserup (1996), and Day and Walter (1987) as noted by Nelson and Sampat (2001, p40). It refers to the broad sense patterned human interaction, or institutions at the cooperative level.

Chapter 3. Research design: concepts, frameworks and methods

3.1 Research design

The core of this thesis is to consider the differences in organisation of DC firms and the corresponding influence upon technological learning in the course of their catching-up. Therefore, it in fact comprises two steps. In the first step, the differences between organisational learning systems of two groups of firms are put centre-stage. In the second step, the role of organisational learning systems is studied, particularly the differences highlighted by the preceding comparison. Throughout this research, the divergence among domestic firms in DCs during their technological learning will be explored, as well as the dynamics of capability growth of local integrators.

The study is carried out mainly through qualitative research methods based on intensive interviews and on-site participations. Domestic firms from China's car-making and telecom-equipment manufacturing sectors are the objects to be investigated. By comparing the two groups of firms, we can see how the differences between organisational learning systems stand out.

The structure of this chapter in fact follows the underlying logics applied to the studies hereafter (see Figure 3.3 below), by looking first at "diagnosis" of the issues (in this section 3.1, on research design), then passes to "selection" of the case studies (in section 3.2), followed by "implementation" of the research strategy (in section 3.3).

3.1.1 Questions and hypotheses

The major purpose of this research is to explore the following question:

"How can local firms in DCs like China change their organisational systems to develop product technologies?"

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To answer this research question, two hypotheses are put forth to examine it:

(1) *There are distinctive organisational differences between Group-A firms and Group-B firms, which exhibit different levels of performance in building the technological capabilities for systemic product development.*

Alternative: *The performance of capability-building mainly relies on strategic resource-based investments. Organisational differences are only marginal factors contributing to learning performance.*

(2) *The organisational differences observed are deeply involved in the processes of knowledge* *search, generation and accumulation.*

Alternative: *Differences in organisational learning systems exist between these two groups of firms. However, they just reflect the differences in strategy of these firms and are not involved closely in knowledge searching and creation.*

3.1.2 Analytical framework

The research analytical framework could be demonstrated as Figure 3.1, Figure 3.2 and Figure 3.3. Among these three figures, Figure 3.1 presents our roadmap of analysis; the Figure 3.2 manifests the components of the "organisational learning system", namely a framework we adopt to explore the differences of firms; and Figure 3.3 is a simple model of the process of the organisational learning system construction in the time dimension.

Figure 3.1 Analytical framework: the reasoning roadmap

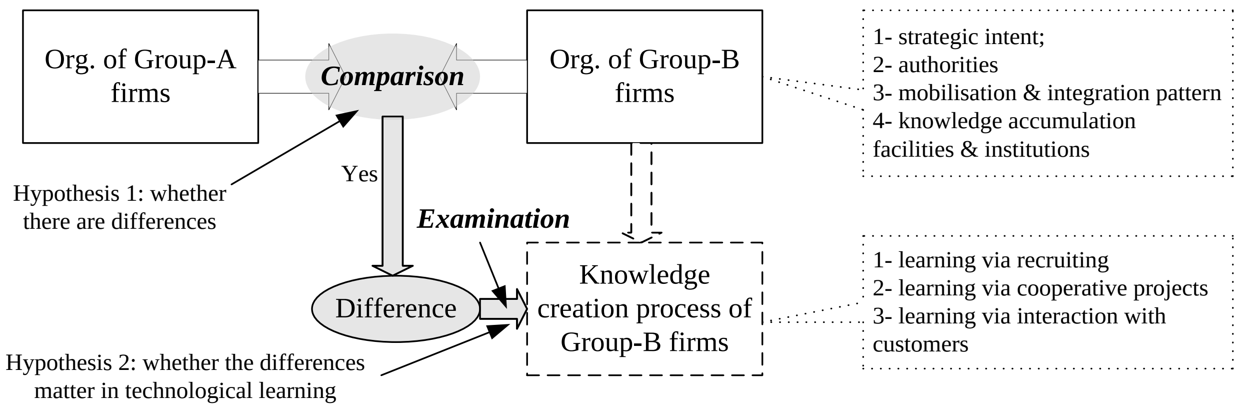
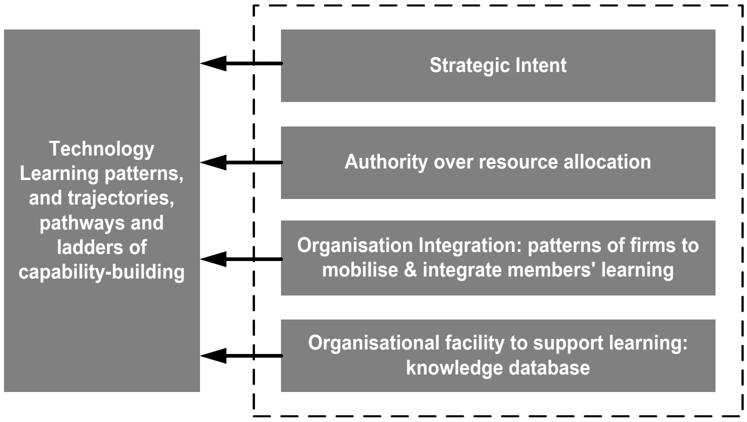


Figure 3.1 presents our reasoning to test our hypotheses and to answer the central question. For the first hypothesis, we study the organisational learning systems of these two groups of firms. Four components are developed to construct the concept of organisational learning system, namely the strategic intent, the authority over strategic resource allocation, the patterns of learning mobilisation and integration and the facilities and institutions for knowledge accumulation. This task is to be completed in Chapter 5 and Chapter 6. As for the second hypothesis, we carry out a detailed study of Group-B firms' knowledge creation processes in their early phase of shifting into a new domain. Chapter 7 is arranged to present the analysis for this task.

Therefore, by investigating whether there are organisational differences, and whether the differences in question are importantly associated with the technological learning process, we bridge the organisational differences with the differences of learning performances of these two subsets of firms.

The framework of the "organisational learning system" is demonstrated as Figure 3.2. The framework is designed by mainly focusing on the organisational process of resource allocation and application. Strategic intent, authority over resource allocation, organisation integration and organisational facility for supporting knowledge accumulation are the three dimensions we study.

Figure 3.2 Analytical framework: the organisational learning system



The ***strategic intent*** can be regarded as an obsession with advancement that encompasses the entire organisation, assuming such an approach is sustainable over a certain length of time (Hamel and Prahalad, 1989; Prahalad, 1993; Hannan and Freeman, 1984, p156). It is usually embodied as the vision of the organisation, the shared competitive or learning agenda, and so on. In particular, it concerns not only the quantity of resources deployed for technological learning but also the organisational pattern of cultural emphasis through which they are used to achieve consolidation.

The ***authority over resource allocation*** is a concept meant to answer two questions: who controls the allocation and through what kind of governance patterns the authority over decision-making is practised. To ensure effective managerial control over strategic resource allocation, two factors are critical. The first is an understanding of who controls the allocation, namely the intra-organisation power distributions (Tushman and Romanelli, 1985, p 175); the second is an assessment of the governance patterns that control how this authority is used. These two elements are significant for understanding the strategic intent through which capability can lead to action.

The ***organisation integration*** includes two parts: the institutional arrangement of organisational mobilisation and the learning integration. It reflects how people are engaged in technological learning within the organisation and how the resources are actually employed. Organisational integration enables capability-building firms to "*socialise participants in a complex division of labour to apply their skills and efforts to the achievement of common goals*" (Lazonick and West, 1995, p 231). In order to achieve an appropriate degree of efficiency of technological learning, indigenous firms should improve their organisational integration as much as possible.

As for the ***facilities and institutions for knowledge accumulation***, we investigate the equity and the role of the knowledge database and underlying supportive institutions. On the one hand, the knowledge databases are the outcome of learning and platforms for collective accumulation, diffusion and application of knowledge. On the other hand, the research about relevant institutions and executions also shed light on the connections between the resource investment for learning and the process of knowledge accumulation, and shed light on the connections between the organisation integration and the knowledge sharing. What kind of knowledge dedication can be recorded, how knowledge is recorded, who has the rights to access it, and how other members apply the accumulated knowledge are questions highlighted for this topic. If (i) the database is built upon an integrated organisation system to which members are effectively mobilised to contribute, and (ii) it can be accessed and applied using a set of rules rather than being retained by departments or by a very limited group of people, we call it a comprehensive knowledge database. This means that either input or output is connected to a broad range of organisational members.

However, in DCs, organisations with high learning performance will not emerge and grow automatically. Figure 3.3 demonstrates the time dimension model of the construction of organisational learning systems of firms in their early phase. Major features of organisations are built up in their early phase along the evolutionary interaction between higher-level learning and lower-level learning. To be specific, the building of organisational learning systems is based on the perceptions of higher-level organisation (decision-makers) about the interaction between the organisational configuration and the learning performance that is produced by the activities of front-line managers, engineers and workers. Therefore, for new entrants or firms undergoing significant reformation heading technological learning in DCs, the cognition of higher-level leaders regarding "what and how learning should be" plays an important role in shaping the organisation and, then, the selection of organisational systems and learning patterns. Consequently, with the pattern selection, the organisation is practically built or transformed. Only after that can strategic resource-based projects be implemented based on the organisational system. Here we develop a framework from Thomas (1994). In his book, Thomas establishes a framework of "*identification – selection – implementation*" for studying the process of technological change, advocating the comparison of stages among different organisations (Thomas, 1994, p13-16). Here, we develop this framework further and employ it to study organisational development, as shown in Figure 3.3. We certainly do not deny the double-loop learning (Argyris and Schön, 1978) and valid learning (March, Sproull and Tamuz, 1991) that occur based on internal tensions and conflicts and change the fundamental norms and rules of organisation, which demonstrates the impacts of organisational implementation on the selection and cognition about organisational configuration. Our framework aims to present a normal sequence of organisational construction or transformation. It is about how the platform for organisational implementation comes, particularly for the DC firms in their early stages of organisational change.

Figure 3.3 Analytical framework: the time dimension of organisation constructing

3.1.3 Definition of terms

In this thesis, we define "technological capability" based on the viewpoint of Bell and Pavitt (1993, p159) as *the capability to generate and manage technological change*.

Particularly, we stress the technological capability of local product integrators. The term "technological integration" is employed in this thesis, but is not part of the main theme to discuss. We take integrators in DCs as our object of analysis for two reasons:

(1) It helps us to identify strategic technological capability. Technological capability is of universal existence, but with a question of degree involved. For the question of degree, consider the situation in global value chains as example. Information-intensive relationships are established within the global chains (Schmitz, 2007, p156). With these relationships, DC firms may have opportunities to participate in relevant global value networks, and even can achieve incremental capability progress with the assistance of global leading firms, or from the "network flagships" (Ernst and Kim, 2002). However, it is difficult for these DC firms to generate and manage technical change beyond the modular interface set by global leading firms. Thus, only the "*knowledge-integrating firms ... relying on their wide in-house scientific and technological capabilities, have the "authority" to identify, propose and implement solutions to complex problems*" (Brusoni, 2005, p1885). Hereby, the term "local integrator" implies the firms we study are firms that provide integrative end-products, and have or had the strategic intent to integrate the knowledge creation.

(2) The concept of the integrator is adopted based on its significant policy implications. Forbes and Wield (2002, p3) "*...contemplate what catching up is all about: increasing value-added through production of goods and services per employee*". In our empirical studies of China's industries, many local industrial enterprises are locked at the assembling and manufacturing ends. What these firms can provide are mainly job vacancies on production lines, or engineer posts for testing or post-sale service, etc, since what support the competitiveness of these firms is the advantage of labour cost. By contrast, the emerging indigenous integrators clearly provide more opportunities for well-paid and comparatively high-standard engineering jobs, and cultivate the local supply chains, since they obviously involve more high value-added activities domestically.

For example, Huawei -- the No.1 Chinese indigenous telecom-equipment provider -- hires about 40,000 engineers engaged in R&D activities, which is much more than the amount of engineers hired by any Sino-foreign JV in this sector. We can roughly estimate that the number of engineers hired by Huawei for product development is larger than the sum hired by all Sino-foreign JVs in this sector. Chery, namely the leading indigenous integrator in the car-making sector, has established a full-set indigenous core components supply chain, many of which had not been achieved by the Chinese industrial community through the TMFT practices in more than two decades.

3.2 Objects of analysis

This thesis is a firm-level study mainly with the support of industry-level analysis. In order to generate persuasive understanding, we go through most of the representative firms in the sectors that we study. In the interest of broader explanation, two sectors that share both common features and distinguished features are selected to carry out the empirical studies.

3.2.1 Sectors selected

Firms in the car-making sector and the telecom-equipment sector in China are the major objects to study. In fact, this research is developed based on empirical studies of a series of sectors, including such as the construction machinery sector, the power equipment sector, the electricity-transmitting equipment sector, the consumer electronics sector and the machine tools sector. In the interest of brevity, only two sectors are included for detailed elaboration. Additional empirical support from other sectors will be applied when necessary for the analysis in this thesis.

In this thesis, the car-making sector and the telecom-equipment sector are selected to provide empirical support for our theoretical argument for the following reasons:

3.2.1.1 Feature of complexity

Knowledge integration is both required for systemic product developers in the two sectors. As to these two sectors, telecom-equipment is broadly categorised as one of the CoPS (complex products and systems) industry, as most telecom-equipment products are high cost and engineering-intensive. These products include a number of customised components, require breadth of knowledge and skills, and require high degree of new knowledge during the processes of being developed and produced (Hobday, 1998; Hobday and Rush, 1999)[13].

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[13] In fact, even the telecom-equipment does not follow the strict definition of prevalent CoPS, since the complexity would evolve. Yes, in this industry customised service and producer-customer interaction are important even today. But as the capabilities of producers grow, they have transferred some complexity of the market, presenting the customer demands, to the product in some mature segments, as implied by Wang and von Tunzelmann (2000, p808), say, producers can have more and more technological features packaged in their delivered products beyond most of the 'customised' demands they

As regards the automobile-making, the prevalent CoPS view has termed it a traditional industry based on standard products and mass production. But in our view, the automobile industry involves frontier technologies of control, thermodynamics, aerodynamics, energy, materials, electronics, etc., which indicates the depth of technological complexity. Besides, automobile-making involves a wide range of technologies as pointed above, and is confronted with different market demands and new processing technologies, i.e. the complexity in breadth (Wang and von Tunzelmann, 2000). To deal with the "internal complexity" and "interface complexity" (Clark and Fujimoto 1991, p10) drives the developers to build corresponding technological capabilities to master the complexities. Such kinds of capabilities, since they are based on interconnected but different disciplinary knowledge in breadth or based on in-depth technical exploration, are not easily obtained through transfer of technology. Therefore, it is easier for us to distinguish among firms whether they have built up such capabilities in-house or they just have developed marginal technological capability but do the manufacturing integration instead.

For example, in the current TV set manufacturing industry, internal complexity has been highly encapsulated into only two assemblies, namely the IC motherboard and the display subsystems, by which the corresponding complexities have been internalised by their suppliers. Therefore, the "integrated product providers" can finish the "product development" only by assembling and executing some marginal technical tasks if they can access the international suppliers of these two assemblies. This is the general situation for many Chinese TV set makers today, and it does not mean they have many abilities to cause or manage technological changes.

3.2.1.2 Different industrial categories

According to the taxonomy developed by Pavitt (1984), the automobile making sector is one of the "scale-intensive" industries, while the telecommunication equipment sector is a "specialized supplier". To be more precise, most automobile producers in China target a mass consumer market, whereas the producers of telecom-equipment in many cases should deal with consumer-specific demands.

The difference between these two sectors in terms of the type of technology adds to the difficulties of the research to some extent. However, it also helps to keep our study from being obsessed or diverted by the sector-specific characteristics, which is important for us to generate a more general understanding about the growth of local integrators in DCs that is applicable to

had ever met. In some segments, telecom-equipment even gradually becomes massively produced as standard products. The router is a typical case, which was strictly a capital good for the giant telecom operators, but now people can buy standardised router products and build family or company wireless/wired computer network. Therefore, we have an opinion of CoPS different from the taxonomy of the prevalent CoPS school.

industries producing complex products from different categories.

3.2.2 Categories of firms

A comparison of organisational learning systems will be implemented between the two groups of firms. They are termed Group-A firms and Group-B firms in this thesis. The firms with which interviews are undertaken for this research are categorized in Table 3.1.

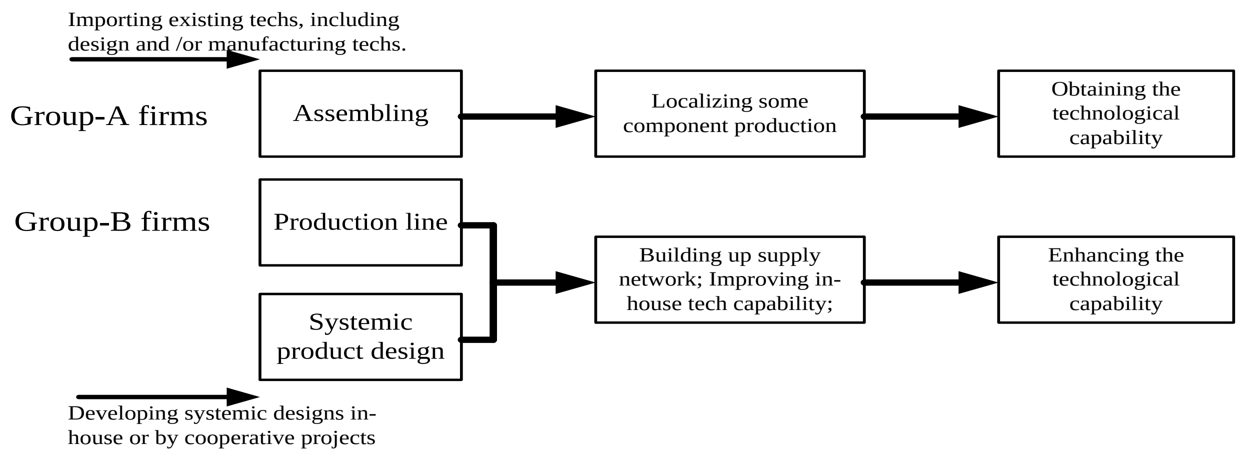
Table 3.1 Categories of firms investigated

	Car-making sector	Telecom-equipment sector
Group-A	FAW (First Auto Works Group), DongFeng, SAIC (Shanghai Auto Industry Co.)	Shanghai-Bell
Group-B	Chery, Geely, HaFei	Huawei, ZTE, DTT, Xinwei
Others	Brilliant	GDT

Note: DTT: Datang Telecom Tech Co.; GDT: Great Dragon Telecom Tech Co.

A key feature that distinguishes the two groups includes the strategy in technological learning. The firms of Group-A follow a bottom-up learning pattern by introducing one or several multinational partners, while the firms of Group-B take a path with which they dominate their product design from their beginning. We can indicate the difference in the technological learning strategy in Figure 3.4:

Figure 3.4 Strategies of technological learning



In order to illuminate the differences of learning strategy between these two groups of firms, we can outline the major products around 10 years[14] after their setup (i.e. the establishment of firms, JVs or cooperation) in Table 3.2.

[14] Usually, according to the level of international mainstream producers, one new product development costs not more than 2-3 years in the automobile making sector; and in the telecom-equipment sector, it is also not more than 5 years from the 1980s. Therefore, 10 years should be sufficient for firms to develop at least one new product if they take the strategy to develop new products.

Table 3.2 Major products in their first 10 years

Group	Firms	Time	Major products
Car-making			
G-A	SAIC	1983 (with Volkswagen *via* JV)	Santana (Passat-B2)
	FAW	1988 (with Audi *via* cooperative production) *1991 (with Volkswagen via JV)*	Audi 100, RedFlag*, *Jetta* (*Vento* of Volkswagen)
	DongFeng	1992 (with Citroën *via* JV)	FuKang (Citroen ZX)
G-B	Chery	1996	Fulwin, QQ, Eastar, Cowin, A5, etc.
	Geely	1998	*HQ* and *MR* series, *Mybo*, *Maple* series, etc.
	HaFei	1983 (for minibus-making); 2000 (for car-making)	Minibus (since 1983): *SHJ* series, *ZhongYi*, *MinYi;* Cars (since 2000): Lubo, Saibao and SaiMa**
Other	Brilliant	1997	*ZhongHua* Series, *Haice* series (MPV***).
Telecom-equipment			
G-A	Shanghai-Bell	1984 (with Belgium BTM *via* JV)	*SSU12 PBX* (Private Branch Exchange*)*, *S1240* PDSS (Belgium BTM)
	Beijing International	1990 (with Siemens *via* JV)	*EWSD* (Siemens)
G-B	Huawei	1987	PBX, PDSS, generally full set equipment for telecom
	ZTE	1985	As above
	DTT	1995	*SP-30*, TD-SCDMA standard and generally full set of equipment***
	Xinwei	1995	SCDMA (R3) standard, and generally full set equipment; McWill (R4, R5) standard & generally full set equipment***
Other	GDT	1984	*HJD-03*, *HJD-04* and complementary devices

*Note: the time referred is for the first import of Group-A firms or for the first product invented of Group-B firms; *the RedFlag is a self-owned brand of FAW. But after FAW setting up a JV with Volkswagen, the RedFlag had been transplanted onto the Audi-100 platform for economic car models, and onto the Lincoln-TownCar platform for luxury car models; **SaiMa is developed based on the Dingo model of Mitsubishi; HaFei imported this model and developed the left-drive version.*
Term: MPV: Multi-Purpose Vehicle; SCDMA: Synchronous Code Division Multiple Access; TD-SCDMA: Time Division-Synchronous Code Division Multiple Access

The sources of differences of their technological learning strategies were related to politics and history. The Group-A firms referred to large SOEs and their JVs with MNCs. Since the large SOEs were the backbone of the industrial economy of China during its era of the command economy, and were under the charge of relevant industrial governmental ministries, they attracted the privilege of political attention, and were influenced by the national strategy of TMFT. The Sino-foreign JVs were exactly established under the TMFT framework during the 1980s and 1990s. To boost the backbone SOEs to establish Sino-foreign JVs, a series of favourable policies, such as special tax treatments guaranteed by the "Sino-foreign joint venture enterprise bill" from 1979 on, were carried out by the government.

As for Group-B firms, most of them were newly established firms or they were SOEs not under the charge of industrial ministries that exactly supervised the industries we study. Therefore, by comparison with Group-A firms, they were not significant enough in terms of scale, investment, human resources or market share when entering the corresponding industries. Moreover, regulations in some industries (such as automobile-making) have also been unfavourable to new entrants, especially to new entrants without government support. Thus, MNCs were not interested in co-operating with Group-B firms during the early phase of the latter.

3.3 Research strategy

The research methods chosen are particularly conditioned by the objects and the central question of research. Our central question is highly related to history and learning processes of firms. Since the case study methodology is more appropriate when "how" and "why" questions are asked about the phenomena drawing on multiple source of evidence (Yin, 2003), the qualitative method, in particular the case study method, is considered essential to this project.

A second reason for us to choose the case study method is that a key point of this research is to explore the capability growth of local integrators in DCs for developing systemic products. There is no systemic index of quantitative measurement for such a subject for us to follow, especially considering its historical and dynamic contexts. In order to achieve the purpose of the theoretical propositions, an analytical framework of case studies is implemented (Yin, 2003).

In addition to case studies, quantitative means are engaged to support time series or contrast studies among firms, which could help to provide a clearer analysis of capability evolution.

We have to admit the qualitative method has its own limitations, especially in terms of ability to represent a broader population of firms. As a result, we cannot claim that the findings we obtain here can be applied to the whole population of Chinese firms or firms in other DCs. Nevertheless, we still look forward to some implications from this thesis for the research community.

3.3.1 Sources of information

There are two major kinds of information sources for this project.

First, there is the information from documents and references, including quantitative and qualitative information. The documentary information is collected as follows:

(i) archives of firms, (ii) press reports, (iii) internal newsletters, (iv) special collections on each enterprise (for example published books or papers), (v) collections of governmental policies and regulations, (vi) special reports on the firm's general and financial situations (especially the public for the listed companies), and (vii) news reports related to the sectors and firms.

Secondly, information from interviews is collected, and can be sorted into two groups, namely from interviews with related academic researchers and from interviews with industrial practitioners during the fieldwork. Besides, on-site participations are employed when investigating two firms since there are convenient conditions to do so.

The interviews that have been done are listed in Table 3.3; and a detailed name list of interviewees is attached as an appendix by following the main text.

Table 3.3 interviews during the fieldwork

Firms	Interviews
Car-making sector	
Chery	4 rounds of in-depth investigation with official support 1 month of close investigation as an internal observer supported by the firm
Geely	2 rounds of in-depth investigation on Geely with official support
HaFei	1st round: in-depth investigation with official support 2nd round: iterative interviews with key persons, which lasted two months
Brilliant	2 rounds of in-depth investigation with official support
FAW	1 round of visiting and interviews with official support 2 rounds of personal interviews with engineers 1 round of investigation with two of its research institutes 2 rounds of interviews with ex-employees
DongFeng	2 rounds of interviews with some employees and ex-employees
SAIC	interviews with researchers
Telecom-equipment sector	
GDT	Interviews with academic researchers; In-depth investigation achieved by colleagues
DTT (& TDIA)	2 rounds of in-depth investigation with official support
Xinwei	3 rounds of in-depth investigation with official support; 1 month of close investigation as an internal observer supported by the firm
ZTE	1st round: in-depth investigation with official support 2nd – 3rd rounds: personal interviews
Huawei	2 rounds of visiting with official support; 2 rounds of personal interviews
Shanghai-Bell	Interviews with academic researchers; 1 round of personal interviews with employees
POTEVIO	1 round of interviews with relevant researchers

Term: TDIA: TD-SCDMA Industry Alliance

3.3.2 Implementation of fieldwork

3.3.2.1. Accessibility of interviews

The fieldwork can be sorted into two stages. In the first stage, I mainly followed several research projects associated with governmental ministries.

The reasons for me to take part in these governmental projects were as follows. (i) It was for cost-efficiency. The firms studied are located in different parts of China so that the travelling for fieldwork generated huge expenditures for traffic and accommodation. To participate in these projects could have a large part of my expenditures covered, though not for all. (ii) Very importantly, governmental projects could make interviews easier to arrange. In most cases, firms are not willing to accept requests for on-site investigation or interviews. However, as China is a society with long tradition of centralisation, most firms are happy to open the door to government research teams in order to have their own voices heard by the policy-makers.

Through governmental projects, I got support from object firms to some extent, especially from those Group-B firms. The phrase “in-depth investigations with official support” that is used in

Table 3.3 signifies that I could make a list of interviewees as I liked to a high degree, and in most cases the object firms would accept my requests. Usually, on the list of interviewees I included the engineers on the shop-floor and in the research centre, the managers of different departments and the decision-makers for the firms. Chery and Xinwei ever provided me with their uniforms so that I could carry out investigation as a fake colleague within their factories and departments, in their conferences with customers, or even at the site of engineering field operations. It provided very good conditions to obtain trustworthy information from their employees.

For most cases, each round of investigation for each firm would last 4-7 days. For every meeting, the common interview periods ranged from 1 hour to half of a working day.

For most of the cases, as referred to in Table 3.3, a second or further rounds of interviews would be carried out in order (i) to diminish the bias created in the information collected when the interviewees were receiving a governmental research team; (ii) to refine the questions according to my needs as the research developed, and to obtain further information.

To achieve these purposes, we attempted to arrange the second and further round of interviews through unofficial personal contacts. In this way, the interviewees could often be more relaxed.

3.3.2.2. Collection of information

For different types of investigation, various tactics were implemented. Regarding the officially supported investigation, a comprehensive list of open questions was used to carry out the conversation. However, the list of questions varied to suit the situations relevant to the posts that interviewers played in their organisations and information that they potentially hold. After that, according to the information that the interviewees had provided, really open questions were put forward to explore more details. Notes and interview records were made during the interviews.

When the meeting was arranged based on personal relations, interviews were arranged usually off-company and casually, and in many cases no records were taken to make the interviewee fully relaxed. This type of interview could help to furnish further details, corroborate other people’s words, comment on other departments and firms, and even register complaints. If notes and records had not been made on the spot, they were made after the interviews were finished.

As Table 3.3 shows, the investigation of Group-A firms at large was not as thorough as the investigation of Group-B firms in terms of rounds of investigation and official support. That is mainly because since January 2005, the Chinese central government has asserted a new policy that is obviously different from the TMFT policy prevalent before, to stress indigenous innovative capabilities. Under the political pressure and criticism of social opinions, the Group-A firms that do not feature themselves with indigenous product development capabilities became unreceptive to visitors. Particularly when the research team I had been taking part in was recognised as a supportive driving force for the policy change, Group-A firms became not so willing to welcome our on-site investigation.

In order to enrich our knowledge about Group-A firms, we implemented a series of interviews with the ex-employees of Group-A firms, including retired employees and those who had quit (many of whom work for Group-B firms now). Again, to diminish the bias of information, the differences between statements were researched carefully and cross-verified.

3.3.3 Analysis and writing up

The interviews, relevant references, published governmental documents, data and documents from industrial associations and company documents are the basis on which the behaviours of firms were identified; then the comparison between the two groups of firms and the analysis of the process of building technological capabilities as integrators was developed.

The analytical strategy was to develop a historical narrative for organising the case study. The narrative as well as the data of firms has helped us to identify the causal relations visible from our analysis. As Huber and Van de Ven (1995, p xii) pointed out, "*Change processes are themselves composed of events with antecedents and consequences, and when these are understood and connected in the form of a story or historical narrative, an understanding of the process is often the result*".

Based on the historical narrative, we build the explanation by stipulating a series of casual relations about the cases, including the explanation of differences existing between the two groups of firms, as well as how the integrators search for, generate and accumulate new knowledge. Iterations are developed to strengthen the important causal relations. Because the relations are complex and difficult to measure in any precise manner, the building of explanation is developed in a narrative form (Yin, 1994)

The information associated with the case study is presented in two main ways:

(i) Firstly, case studies are presented as "an analytic chronology", which is the historical narrative of evolution of institutions and policies. It is adopted in Chapter 4 and 8 to demonstrate how the institution influences the learning strategies of firms in China.

(ii) Secondly, the case studies are organised according to "a theory-building structure", which aims at interpreting the stories by comparison with the generation of a theoretical framework, and which also seeks to demonstrate the relevant cases supporting the process through which the capabilities of the integrator are built up. This kind of pattern is adopted in Chapters 5, 6 and 7.

Chapter 4. Background: institutions, industries and firms

4.1 Introduction

The two groups of firms we study in this thesis did not emerge naturally from the market-oriented reformation of China. In this chapter, the national and sectoral backgrounds are explored. The mechanisms through which national and sectoral institutions influence the learning strategy and organisational systems of firms are the focuses. The emergence of these two groups of firms is here regarded as the outcome of an evolution of a governmental pattern of industrial governance. The Group-A firms were encouraged to build up JVs with MNCs by the government. The Group-B firms were built by their founders independently from the central planning system, and being confronted with the unfavourable treatment of the governmental industrial administration they had to find niche markets for survival in their infancy stages. So why did the institutions work in this way? To explain the institutional backgrounds is important for understanding the emergence and underlying organisational features of these two groups of firms.

The backgrounds are explained in two parts, namely the role of the government and that of the industrial ministerial system during the reform, as presented in section 4.2. We analyse the emergence and general learning patterns of these two groups in sections 4.3 and 4.4.

The performances of these firms share commonalities in terms of the expansion of production capacity in general but with different roles for incumbents and newcomers especially in terms of the technological capability growth. We present such a comparison in section 4.5.

4.2 National industrial governance system

China operates a transitional economy. It has developed a gradual reform instead of the shock therapy from the late 1970s on towards a market-oriented economy. Even the previous institutions of central planning system continue to be reformed. Their legacies still have impacts on its industrial system during the course of reform, although the impacts are uneven in different fields and followed evolutionary trajectories.

In its over 60 years of history, the government, especially the central government, played a leading role in the industrial economy of the PRC (People's Republic of China), either during the command economy era or the reform era after 1978, which differed just in extent. This phenomenon goes beyond the specificity of socialism ideology, but is a complex outcome for socio-cultural, political and path-dependent reasons. China is a country with traditions of centralisation over a thousand years or more. Centralisation is respected as the orthodoxy in its social culture. After becoming a socialist country in 1949, the Chinese had opportunities to learn from their political allies, and built up their industrial administrative system by imitating the USSR system of the 1950s. Importantly, the first round of massive industrialisation in China in a truly modern sense was practised as a top-down governmentally organised movement. It was raised in the 1950s being similar to a Gerschenkronian strategy as stressing the capital goods heavy industries and scale economies of production. The "156 projects" executed in the 1st FYP (Five-Year Plan) with the assistance of USSR and other socialist countries and the projects of this kind in the 2nd FYP were the historical foundations of Chinese modern industries. Meanwhile, Chinese government built up a series of indigenous supportive projects[15]. In a word, the skeleton of Chinese modern industrialisation was realised by top-down governmental forces rather than by the private sector or other decentralised forces. This industrialisation with the following efforts during 1960s-1970s gradually brought China partly into a modern industry-based society[16]. Such a framework of an industrial system still works significantly today.

Our analysis below is developed through two connected topics. Firstly, we introduce briefly how much the Chinese government is directly involved in the industrial economy. Secondly, we introduce the means and institutions by which the government realises its impacts on industries. These analyses are helpful for our understanding of the emergence of the firms we study.

4.2.1 Role of central government: holding economic units

There are many ways for governments to impose their influence on industries. In China, holding economic units directly was an important way of this kind. The categories of units that the government owns include industrial firms, research institutes and universities. During the reform, the situation had been changed but not eliminated. The practices performed by the government on units it directly held led to the emergence of Group-A firms, and shaped the inducements for that of Group-B firms indirectly.

Chinese reform in the industrial sector, starting in 1978, is in essence a decentralisation of central planning. It can be divided into two phases (Qian, 2001). (i) The first phase was represented by the expansion of managerial autonomy. As for SOEs, instead of the governmental direct coordination for corporate management, the "*factory director responsibility system*" was encouraged after 1982, and the "*contract responsibility system*" after 1986. By 1988, 83.2% of

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[15] The cooperative projects with USSR were initiated from 1950, and were stopped in 1960 by Khrushchev. During the 1st FYP (1953 – 1957), 156 cooperative projects were initiated mostly in the field of military-related, resource and heavy industries. And after the 1st FYP, a series of consequent cooperative projects were signed by USSR and China. In the entire 1950s, there were 304 full set equipment projects and 64 single workshop or equipment projects agreed between the two countries. Among them, 149 of full set equipment projects had been fully or partly established before the Sino-Soviet Split, while 89 of them were cancelled; 66 projects were continued by Chinese on their own. As for the independent workshops or equipment projects, the corresponding numbers were 29, 35 and 0 (Zhang, B., F. Yao, et al., 2004). Several East European communist countries also provided China cooperative projects. By these projects, China got blueprints, equipment, technical advisers and some loans from these communist countries.

[16] For the crucial role of the projects built by the central government, we can see from the contribution of the "156 projects" in the 1950s. At the end of the 1st FYP, the contribution of these 156 projects to the entire outcome of corresponding industries ranged from 72.9% to 100% in the steel-making, iron-making, steel-rolling, aluminium-making, automobile manufacturing and electricity-generating industries.

SOEs had adapted the "*factory director responsibility system*" (Shan, 1991) and obtained the autonomy regarding operational managements. (ii) The second phase was marked as the "modernisation" of corporate governance. This phase could be represented by three changes. First was the privatisation in a practical sense, by which the public shares of SOEs were sold to the private sector or employees. Second, as for the rest of the public shares, the market-oriented ownership relations between government and firms took the place of the previous governmental direct imperatives. Third, the contract-based industrial relations came instead of political relations and lifetime employment within SOEs. By this reform, the term "State Operated Enterprise" was replaced by the "State Owned Enterprise" officially in 1993. It meant in theory that the government changed its role to be a share-holder instead of an imperative commander. Besides, after another round of reform starting from 1998, the ownership of SOEs held by the government were taken away from industrial ministries to a new special governmental agent which was later named as SASAC (State-owned Assets Supervision & Administration commission of the State Council) in 2003. The SASAC was designed to preserve and increase state assets. That was to say, in theory only the asset-supervision relation was left to the industrial administration. During this course, most medium and small sized SOEs were given up from the direct control of central government, but transferred to the private sector, or controlled by the regional governments or other large state-owned industrial groups. By 2009, only 136 large SOEs and industrial research institutes were directly held by SASAC (this number varied with time). In theory, the scale and scope of the governmental direct intervention in industrial firms has been largely reduced, especially that of the central government. The below Table 4.1 presents a comparison among the situations in 1978 – the starting point of reform, in 1997 – the point when all firms studied in this thesis had been established, and in 2005 – the point when Chinese policy-makers began to stress the indigenous innovative capability.

Table 4.1 Shares of GDP

	GDP, % share		
Year	1978	1997	2005
Gross	100	100	100
-1.Public ownership economy	99.1	75.8	35
--1.1 State-ownership economy	56.2	41.9	
------- mixed ownership included	__	6.5	
--1.2 Collective-ownership economy	42.9	33.9	
------- mixed ownership included	__	2.2	
- 2. Non-public ownership economy	0.9	24.2	65

Source: China Statistical Yearbook (2002) and All-China Federation of Industry and Commerce.

In the two sectors of our study, there are several firms in the list of SASAC, including FAW, DongFeng and China National Auto Joint Company in the car-making sector, and POTEVIO, China Academy of Telecom Tech. (CATT), Shanghai-Bell, Wuhan Research Institute of Post & Telecoms (WRI), China Post & Telecom Appliances, and China Information Tech. Designing &

Consulting Institute in the telecom-equipment sector.

However, we cannot simply conclude that the government has decided to give away its influence on industries. The top decision-makers in SOEs, if they are appointed by governmental agents or SOE investors, are still somehow connected with the human resource system of corresponding governmental departments. Therefore, only if the government wants to impose its influence on these firms, it does have the potential. As for those mixed-ownership firms when the public share does not dominate, the government still has possibilities to persuade the other decision-makers by its agents; the extent of the governmental efforts in doing this depends on the kinship and significance of firms to the government. Besides, the government owns other policy instruments to exert its strategies. It maintains a regulation of large investment for the sake of economic security against overheated investment and industrial security. By this instrument, barriers to entry in some pillar industries are kept to actualise the governmental schemes. Indirectly, most domestic giant commercial banks are SOEs, which also can be mobilised if needed.

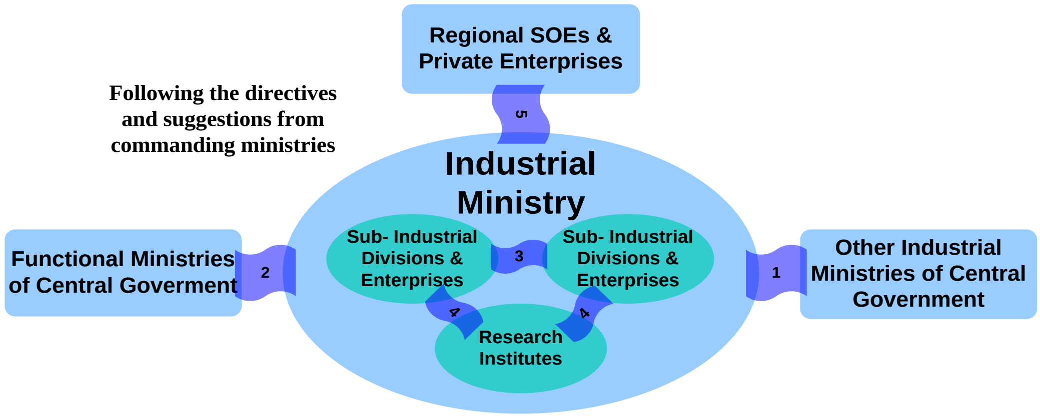
4.2.2 Industrial ministries: branch-based industrial administrative systems

Regarding the industrial-specific activities, the governmental role was realised by a series of governmental departments and agents. Among these agents, the industrial ministerial systems must be stressed. They worked as the front-line strategic headquarters within the corresponding industrial domains, and implemented highly specialised administration, while keeping arm's length coordination with other ministries horizontally.

The ministry-level departments of Chinese central government during most of the 1950s-1990s periods could be categorised into four groups. Only a few of them, working as the command ministries or commissions, had the superpower to make gross schemes both for industrial sectors and regional sectors, and to mobilise relevant resources. The settings of this kind varied with the phases of reform. Only the State Planning Commission (SPC) was always kept as a leader, although its name was also changed from period to period for the reconstruction of ministries. The second group included functional ministries to take care of specialised governmental functions, e.g. the affairs related to finance, labour and personnel, customs, etc. A third group included some special ministries and agents, such as the SASAC, which were set to take the responsibility for some special needs.

A fourth group comprised a series of branch-based industrial ministries. Following the directives and suggestions of command ministries, being associated with functional ministries, and keeping arm's length cooperation with other industrial ministries, industrial ministries were the practical front-line strategy-makers and commanders representing the central planning. They owned the SOEs (MOEs hereafter, ministry-owned-enterprises), research institutes and universities held by the central government in their respective industrial domains, which were all backbone entities at country-level[17]; as for other economic units they did not directly own, they played a industry-specific regulative and advisory role. In sum, industrial ministries worked as the hub of information-collecting and policy-making of industries (see Figure 4.1). This situation had not been ended until approximately the reform in 1998.

Figure 4.1 Roles of Industrial Ministries in the Central Planning Economic System



Industrial ministries constructed systems with high-specialisation, which included endogenous specialisation and exogenous specialisation. The exogenous specialisation was based on the specialised coupling of particular ministry and corresponding industrial sector, which meant that these ministries were industrially branch-based, as described by von Tunzelmann (1995) about the USSR case. During the 1950s-1980s, the extent of exogenous specialisation grew as the Chinese industrial system developed, by which we refer to the growth in the number of industrial ministries. More and more industrial ministries were established to cope with the expansion of industrial scope, and to promote the specialisation of administration. In the machinery-related fields, the number of industrial ministries grew from only 1 in 1949 to 7 in the early 1960s and 13 by the end of the 1970s. Even after a simplification reform in 1982, there were still 8 specialised industrial ministries in the machinery-related fields. Such an arrangement separated the industries with arm's length coordination. For example, in the domains relating to machinery, the industries of agriculture machinery, automobiles, aviation manufacturing, electronics and computers, broadcast and televisions, etc., were governed by separate industrial ministries in the early 1980s.

The endogenous specialisation came from their governance pattern. Firstly, within each ministry, science and technology development activities were put into one or several divisions independently from those for manufacturing and other activities. It was set to follow the tradition

[17] The backbone SOEs, institutes and universities owned by industrial ministries were large in number. For example, in the reform starting from 1998, there were still 270 research institutes that were reformed away from the direct supervision of ministries, even if we did not count those having been reformed during previous rounds.

of the USSR (Berliner, 1976; Gu, 1999), and aimed at the scale economies of science and technology development, and avoiding the waste of resources in theory. However, it caused the horizontal disconnection of S&T from production in practice (Z. Zhao, 1985[18]; Gu and Lundvall, 2006). Secondly, the administration was meanwhile categorised into different segments based on technical or sectoral dimensions, which could be regarded as further specialisation following the exogenous specialisation. X. Shen (1999, p20) describes the internal specialisation of the MPT (Ministry of Posts & Telecoms) in 1995, by which not only the administrations for different regulation functions but also the administrations for the activities and directly-owned entities in equipment manufacturing, plant scheming, network construction, broadcasting and satellite were under the charge of different division.

Therefore, industrial ministries were built into not only the supervisors of corresponding industrial systems, but also one part of the real industrial practices: they exactly acted as the integrators of information and knowledge, as well as the planners of resources, production and distribution. Not only for the information and resource flows among different sub-industries, but also for the flows between corresponding industries and other external industries, industrial ministries indeed were the only platforms to play the integrative role. The command ministries or the state council, although ranked higher in the bureaucratic system, did not control the industry-based information directly; as for the lower level bureaus or economic units, they did not have channels to connect and mobilise relevant information and resource forwardly.

A question can be raised here: if the most important changes in corresponding industrial domains were made by industrial ministries, how could the central government deal with so much information? In fact, regarding incremental changes and routine cooperation among economic units, administrations were achieved through the "*GuiKou management*" system, which was an important governance component for the central planning system.

The "*GuiKou management*" was the practical pattern that ministries governed MOEs, subordinated research institutes and universities. "*Gui*" means "belonging" literally; "*Kou*" means the department, division or branch. Therefore, "*GuiKou management*" meant the state-owned entity must comply with the appointment to carry out its duties in a particular branch set by the ministry. More specifically, it meant that entities (i) were put under the supervision of a specific division of industrial ministry, (ii) were located at an appointed geographical site, and (iii) were designed to produce particular products or carry out appointed activities. The latter two points were usually applied with another phrase, namely the "*designate firm/ institute*" ("*Dingdian*" in Chinese), which referred to the firm/institute under such a system. The product that industrial

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[18] ZiYang Zhao was the Premier of China at that time.

firms were appointed to produce could be very specific according to the requirements of a central planning system, such as "kinescope production" or "circuit production and TV set assembling".

The "*GuiKou management*" system also defined the particular routine linkage among economic units. Take a ministry-owned industrial research institute as an example. Such a system indicated the field the institute worked in and with whom it should regularly cooperate. By this, factories and institutes were coupled to develop and produce appointed products in appointed time in appointed place and in appointed amounts.

Certainly, the situations and the relevant influence of industrial ministries changed gradually during the reform. Most industrial ministries had been reformed away in or prior to 1998, except for the MII (Ministry of Information Industry). However, the removal of influence of the former central planning system lagged behind the physical reform of bureaucracies. The legacy of the central planning system and industrial ministries still had obvious influence, as the industrial relations formed in that era had been embedded and influenced the decision-making of firms informally. In the early phase of reform, it was usually still the ministries working as organisers to facilitate the cooperation among economic units. The influence of ministries over state-owned entities made sense, but we also could not ignore that the inertia of these economic units made them deficient in terms of abilities (embodied as experience or even personal skills) to mobilise information and resources from a broader scope. In a word, the market-oriented reform could not change them into competitive units under market competition in just one day (F. Lu, 2000). In many cases, SOEs and former SOEs were likely to listen to the government as they were formally bound by the institutional arrangements. Such an environment explained the fast diffusion of TMFT practices among firms during the 1980s-1990s.

4.3 Emergence of Group-A firms

In the early 1980s, in order to speed up the technological catching-up, China began to adopt the TMFT policy, which was taken as a national primary strategy until 2004, and directly led to the emergence of Group-A firms.

The TMFT should not be understood straightforwardly as introducing foreign firms to occupy the domestic market if these foreign firms were willing to help the domestic industrial community to promote technological capability. Endowed by its birth process, the TMFT policy in practice entailed a preference in learning patterns and trajectories. In short, under the TMFT framework:

(i) SOEs were encouraged to set up productive JVs with MNCs;

(ii) Group-A firms were encouraged to learn "closely" and day by day from their foreign partners;

(iii) Following the above two points, Group-A firms were in practice encouraged to learn through a reverse sequence of the normal product life cycle, which was typically similar to the bottom-up model described in the relevant literature (e.g. Kim, 1997, p89).

The TMFT policy was invented based on its victory over other competitive policies from 1972 onward. Its policy components, as listed above, were developed through a policy controversy.

4.3.1 Contemporary policies for importing foreign technologies

Before the TMFT framework, there were several other policies implemented by China to import foreign technologies to promote indigenous technological learning. The Sino-Soviet cooperation in the 1950s was exactly a success of this kind. After the Sino-Soviet split in the late 1950s, Chinese policy-makers began to look for technological cooperation with foreign countries. Before the 1972, only a few instances of international technological cooperation were carried on[19]. Only after the visit of Nixon to China in 1972 could the Chinese establish official and large-scale technological connections with the western world.

From 1972 on, the SPC proposed a program to import complete equipment sets from abroad. Many heavy industries were involved, namely metallurgy, fertilizer and petrochemicals. This program was carried out during 1973-1978, with a total budget of 4.3 billion USD, and was named as the "43 Arrangements" in China's governmental documents[20]. With domestic complementary investment at around 20 billion RMB, 27 large-scale industrial projects were finally set up (for details, see Naughton, 1996, p67-74).

In 1977, a second national-wide plan for foreign technology importation was put forth with 120 large industrial projects, which were begun to practise from 1978 on and then called the "78 Plan". The Chinese central government decided to adopt more methods of technological importation. Diversified patterns, including compensatory trade, OEM, process materials supplied by clients, commission sales and cooperative production were employed. Besides, Chinese delegations were sent abroad to looked for successful experience for rapid industrialisation. As the consequence of the "open-door" shift, foreign capital was introduced in the form of loans. To establish Sino-foreign JVs with investments from capitalist countries, as a highly sensitive area connected to the ownership that was regarded as the heartland of the socialist economy, was also relaxed at least nominally. The "experience" brought back by the delegations to Yugoslavia and the United States (led by Deng) worked critically for the shift entailing ownership. In fact, during the "78 Plan", the negotiation of several JVs projects that were later formally supported by the TMFT

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[19] For instance, the *LT Memorandum* (*Liao-Takasaki Memorandum*) which was signed by China and Japan in 1962 was a quasi-official agreement for international trade (the formal diplomatic relation was established in 1972). However, in this agreement, only minerals, agriculture products and other goods (China side), and steel, fertilizer, pesticides, agricultural implement and machinery, some complete equipment, and other goods (Japan side) were involved.

[20] With extra supplement projects, the total expenditure of "43 Arrangements" was exactly 5.14 billion USD.

framework had already been started, such as the Shanghai-Volkswagen project.

Along with the development of "78 Plan", the method of importing complete equipment sets that prevailed from the "43 Arrangement" was criticised for its significant cost of financial resources. The 22 large-scale projects initiated in 1978 alone cost 13 billion USD as importation fees and more than 20 billion RMB as investment to domestic complementary projects. The value of those contracts signed in the last two months of 1978 only had reached 7.8 billion USD, which was equal to 89.2% of the total technological importation fee during 1950-1977. By contrast, the forex reserves of China in 1977 and 1978 were only 0.952 and 0.167 billion USD respectively. After the policy-makers were warned of the severe unbalance of international trade and shortage of forex in 1979, a sharp decrease of importation in 1980 had to be made. Only 67 contracts were signed in 1980 while there were 346 contracts in 1979 (Li and Huang, 2001, p648).

As a result, intensive controversies were raised among policy-makers. The method of importing complete equipment sets was forcefully criticized for the reasons claimed as follows (Li and Huang, 2001):

- *The strategy of importing complete equipment sets depressed the domestic sector of capital equipment production.*
- *The Neglect of the importation of complementary process technologies and capital equipment making technologies had the manufacturing capacity not been improved as expected.*
- *For the limited domestic absorptive capacity, without effective organisation of relevant firms and institutes to study the imported equipment, the absorption, acquisition and re-invention of imported technologies had not occurred as expected.*
- *The average cost of imported equipment during 1973 -1982 was found to be higher than in international markets, especially when taking the cost of Japan's equipment imports during 1970 – 1979 as a bench-mark.*
- *The equipment imports during 1973 -1982 were out of control, which had destroyed the forex balance and the macro-balance of the planning industrial system.*

As indicated, problems were pointed out for the method of carrying out importation of complete equipment sets, which were in practice related to the weakness of China in finance, absorptive capacity, and managerial capability of that time. Accordingly, the opponents suggested implementing methods characterized by higher packaged technological transfer (Radosevic, 1999).The experience gained by Chinese delegations from the visits to Yugoslavia and Romania recommended the patterns of technological importation by using technical licensing, turnkey engineering projects, cooperative production and JVs (Li and Huang, 2001, p649). The opinions of the returned delegations unbalanced the controversy of that time, and strengthened the inclination to look for "low cost" and "high efficiency" patterns. More importantly, Deng's visit to the United States speeded up the pace of economic reform. He decided to establish "China's characteristic way of modernisation"[21]. To make use of international resources of western countries and to learn from foreign partners was regarded as a primary method to realise such a target[22]. After a series of discussions, policy- makers sent out the message that ownership was no longer a forbidden topic. The controversies finally led to the emergence of the TMFT policy as a national strategy of industrial development. The political change, the leading policy-makers' view about the market-oriented economy and relevant economic reform, the practical shortage of forex and the lack of satisfaction afforded by other patterns jointly engendered such an outcome.

We must state that even with the prevalence of the TMFT policy, other patterns were still applicable. Nevertheless, without doubt, TMFT played the leading role in China's industrial development policy from the mid 1980s to 2004.

4.3.2 Policy of "Trading Market for Technology"

As a policy package with practical action plans, the TMFT policy was firstly put forth by policy-makers in the automobile industry, and stressed import substitution and technological catching-up together as strategic targets.

In practice, a report to the State Council in 1983 submitted by Bin Rao[23], namely the director of CNAJC (China National Automobile Joint Company)[24] at that time, was broadly taken as the origin of TMFT thinking. The report advocated introducing foreign technologies by carrying out cooperative production not only in the automobile industry, but also in the entire industrial sector. The report took the acceleration of indigenous technological capability building and the import substitution as its targets.

At the time, the Chinese domestic automobile industry was confronted with severe challenges. Since China began to open its market to western countries, the amount of imports was increasing at an unusually high rate. Particularly in the car sector, imports exceeded the entire production capacity of the domestic industry in a very short time (see Table 4.2). In 1985, the amount of imports was 20 times the domestic production capacity.

Table 4.2 Tendency of cars imported in early half of 1980s (unit: set)

Year	1981	1982	1983	1984	1985
Cars imported	1401	1101	5806	21651	105775
Cars imported / all vehicles imported	3.37%	6.85%	23.08%	24.40%	29.88%
Cars imported / Cars produced domestically	40.87%	27.32%	96.03%	360.25%	2031.40%

21 Documented in his speech in March 1979.
22 Documented in his speech in Dec. 1979.
23 Rao was the leading founder of FAW, SAW (now DongFeng), and the Shanghai–Volkswagen project. He acted as the director of Bureau of Automobile Industry and the Minister of No.1 MMI from 1979. Therefore, Rao was an influential person, physically and mentally for all machinery relevant industries in China.
24 CNAJC was transferred from the automobile division of No.1 MMI, and acted as the practical administrative agent of the automobile industry at the ministerial level at that time.

Data source: China Automotive Industry Yearbook 2003, p26

The fast growth of imports exposed the forex reserves to continuous pressure, and depressed the domestic production. Therefore, in his report, Rao, as practically principal officer of China's automobile industry at the ministerial level at that time, described that (Teng, 2003):

"[I]n the past ten years, about 272 thousand sets of automobiles were imported… and the expense reached 11.2 billion RMB (the import expense for parts and components was not figured yet), which was 12 times the historical accumulated investment of FAW…"

"(Therefore) we should combine the technology trade and product trade together, as well as stressing the future export capacity. China's automobile industry should take the path of importing foreign advanced technologies and carrying out cooperative design and production…"

--Rao, *Proposal for Stressing the Technology Trade in the Product Importation o f Automotive Sector* (Oct, 1983)

Later, the thinking of Rao was intentionally stressed by SOE practitioners as "*introducing foreign investment and technology/product design, and increasing the manufacturing localisation of parts and components* (Rao, ibid)", when they were criticized for not cultivating indigenous technological capabilities. However, the following speeches testified that the initial target of TMFT was to promote indigenous technological capability in addition to import substitution. In the "National Planning Conference of the automotive industry" organised by CNAJC in the December of 1985, the vice premier of China at that time, namely Peng Li, insisted, "*[regarding the aims]…we should not keep producing car models designed by foreign partners. Our strategy should address importing foreign advanced technologies, building up in-house product designs and developing the indigenous automobile industry…*"

In the same conference, Rao outlined his thinking by discussing the specific case of Beijing-AMC, namely the first Sino-foreign productive JV in the car-making sector: "*I do not stress how many cars you can produce in a year, or how much profit you can earn. I care about how fast you can launch your own new car designs….I expect you to launch in-house new car models in 3 years…. It is the primary request I have.*"[25]

Thus, the TMFT policy was indeed designed with double targets by its initiators, namely to realise the import substitution and efficient technological learning. For these purposes, the Chinese government took on the cost of rendering the domestic market share for potential foreign partners, in order to expedite the bilateral cooperation and the technology learning on the Chinese side.

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[25] The two speeches are provided by BoLe Teng (RAO's secretary in the 1980s) in a interview by the *21st Century Economic Report* (2008-09-24, title: ZhongWai HeZi DiYiDan: "ShiChang Huan JiShu" Shi ZheYang Bei YiWang De (The First Sino-foreign Productive JV: How original targets of TMFT were getting forgotten).

In fact, several Sino-foreign cooperative projects had already been under negotiation before 1983. Rao himself had already proposed to import a production line of automobiles and to cooperate with the foreign side in production in 1978. For this proposal, the negotiation of Chinese government with Volkswagen had begun from 1978, which finally led to the JV between SAIC and Volkswagen from 1985 on[26]. The Beijing (Beijing Auto) – AMC (United States) was the first JV project in the Chinese automobile industry. The relevant contract was signed in 1983. Meanwhile, the JV contract for Shanghai-Bell was signed in 1983 and was the first in the sectors related to electronics and telecommunication.

For those policy-makers who were occupied in a controversy and looked for better patterns, Rao's idea of introducing foreign technologies by carrying out cooperative production was quickly accepted. Such a consensus speeded up the above negotiation processes of existing projects. Other ministries all followed this pattern so that to establish Sino-foreign JVs became widely encouraged in China's industrial community.

In the automobile industry, 71 productive JV projects and 5 technical cooperation projects were signed during 1983-2000. Among these 76 projects, 58 introduced foreign technologies in the form of equipment, blueprints, licences and training. If counting in the projects concentrating on parts and components, 557 JVs had been established before the end of 1998.

In the car-making sector, the backbone SOEs embodied a "6+3" skeletal structure (see the following section 4.4.2.1). These SOEs were those supported by government in the central planning system, since policy-makers believed that large-scale production capacity was necessary for efficient technological learning. All of them had established JVs with MNCs except for HaFei Auto (see Table 4.3)

Table 4.3 Sino-foreign JVs established by "6+3" SOEs in the car-making sector

SOEs	First partner	Current partners (2009)
FAW	1988 with Audi (CKD)	Volkswagen (JV, including Audi); Toyota (JV), Mazda (CKD), Daewoo (JV)
DongFeng*	1992 with Citroën (JV)	PSA (JV, including Citroën), Nissan (JV), Honda (JV), Kia (JV)
SAIC	1983 with Volkswagen (CKD)	Volkswagen (JV), GM (JV)
Beijing	1983 with AMC (JV)	DaimlerChrysler (JV, including AMC), Mercedes-Benz (JV), Hyundai (JV)
Guangzhou	1985 with Peugeot (JV)	Toyota (JV), Honda (JV)
Tianjin**	1986 with DAFA (Japan) and Toyota (model procurement)	Toyota (JV)
ChangAn	1993 with Suzuki (JV)	Suzuki (JV), Ford (JV), Mazda (CKD)
ChangHe	1994 with Isuzu (JV)	Suzuki
HaFei	NA	NA

*Note: * other than the JVs, there is no production line for passenger cars in the DongFeng Group*

[26] The contract was signed in 1984, and the JV was built in 1985.

*now;*** Tianjin automobile was acquired by FAW in 2002*

Policy-makers in the telecom-equipment sector were also early advocators of TMFT thought. In discussing the proposal to set up the Shanghai-Bell, JinFu Zhang, a State Councillor representing the highest governmental authority in the development of this industry, gave guidance as follows:

"(Our) strategy is to exchange the market for technologies. We should import, assimilate and absorb high technologies from foreign partners. The aim is to promote our design capability and manufacturing capacity….Cooperative efforts are the goal. Chinese and foreign experts should design and build each department of the JV together… Assimilation, absorption and re-innovation should be preserved continuously based on the imported technologies."

–Zhang, Speech in the conference of "*The feasibility study of the Sino-Belgian cooperation of digital PDSS*", 1983[27]

In this sector, Sino-foreign JVs were also set up quickly, as shown in the following Table 4.4.

Table 4.4. Sino-foreign JVs established by MOEs in the telecom-equipment sector

PDSS Models*	JVs	Foreign nationality	Chinese share	Time of founding	contracted production capacity (unit: lines/year)
1240	Shanghai-Bell	Belgium	54%	1984	2000,000
F-150	Jiangsu-Fujitsu	Japan	35%	1987	500,000
DMS-100	Guangdong-Nortel	Canada	60%	1988	1000,000
NEAX-61	Tianjin-NEC	Japan	60%	1989	1000,000
EWSD	Beijing international	Germany (Siemens)	60%	1990	1000,000
AXE10	Nanjing-Ericsson	Sweden	43%	1992	500,000
5ESS	Qingdao-Lucent	United States	49%	1993	1000,000

*Note: *the PDSS model imported at the very beginning*

It is worth noting that the TMFT policy was not elaborated by any formal official document until 1993. However, it still became a popular and respectable political term. For the support from the highest authority and the in name of catching-up, it received active response from industrial ministries. The fast spread of TMFT practices could be testified by the share of FFEs in Chinese industries, which included the Sino-foreign JVs as the outcome of the TMFT policy[28]. Table 4.5 is based on the 3rd national general investigation of industries, and it manifests the rapid growth of the significance of FFEs. By the end of 1995, 27 sectors were dominated by FFEs with over 60% market share.

[27] In, page24, Wu, J. and G. Xi, Eds. (2008). GaiGe KaiFang ChuangXin: Shanghai BeiEr FaZhan Zhi Lu (Reforming, opening and Innovating: the pathway of Shanghai-Bell). Beijing, People's Press.

[28] Before 1993, TMFT was the only policy nominally encouraging the entity-relevant investment of FDI.

Table 4.5 Industries with over 30% market share occupied by FFEs (end of 1995[29])

Share	Amount of sectors	Sectors
30% -- 40%	50	**minibus**, motorcycle, , consumer chemical, etc.
40% -- 50%	26	semiconductor, clothing, motorcycle, etc.
50% -- 60%	30	**telecom-equipment**, electron device & component, etc.
60% --	27	**cars**, telecom terminal, computer, ICs, radio and recorder, etc.

Data source: National Bureau of Statistics of China

Note: there was no FFE with 100% foreign share in the car-making sector, which was ruled by industrial regulation

4.3.3 Supportive policies

In order to facilitate the TMFT practices, Chinese government implemented a series of favourable treatments, especially in the domains of taxation and import tariffs. These policies constructed the TMFT framework into a likely profitable business model to both the domestic and foreign sides so as to promote the attractiveness of the TMFT policy.

(1) Favourable taxation treatment

In 1991, the special tax treatment was offered to FFEs by the "*Income Tax Law of PRC for Enterprises with Foreign Investment and Foreign Enterprises*". After that, China tried to unify the income tax rate for all investment in the country by a bill named as the "Provisional Income Tax Regulations" which was put into effect in 1994. The later was aimed to unify the nominal income tax for all enterprises to 33%. However, in order to attract FDI, the 1991 law was still applicable. Therefore, with all kind of incentive arrangements, the virtual income tax rate for FFEs was only 11%-15%. Meanwhile, the virtual income tax rate for domestic investment was 23% in general. Nevertheless, for large SOEs, the rate was still kept above 30%. By counting in the residual taken away by the government, the practical tax rate for SOEs was much higher which in many cases could reach 55% (H. Zhang, 2004).

In addition, there was a "*two-year exemption and three-year reduction by half*" treatment granted to FFEs. It meant that those FFEs that satisfied certain requirements were entitled to tax exemption for the first two years of profit-making and reduction by 50% for the following three years. Import duties and VAT for machinery and equipment were also exempted for FFEs.

Therefore, special tax treatment attracted foreign investors since by comparison with domestic investors and SOEs they apparently had advantage in terms of taxation. The situation was not changed until 2008, when a new "*Enterprise Income Tax Law"* came to unify the nominal income tax rate for all firms to 25%, and to abolish both the 1991 law and 1994 law.

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[29] The year 1995 was a special year, since Group-B telecom-equipment firms would challenge incumbents soon through a price war of PDSS. And several Group-B car-making firms were also preparing to establish themselves.

(2) Favourable import tariff treatment

Import tariffs were also adjusted to support Sino-foreign JVs. In the automobile industry, government lifted the import tariffs from 1985 for completed products and lowered those for components, which led to the popularity of the CKD and SKD (Semi-Knocked Down) production patterns in China from the mid 1980s. Table 4.2 and Table 4.7 demonstrate the effects of tariff adjustment and Table 4.6 exhibits the detailed tariff settings.

Table 4.6 Import tariffs for the importation of cars

Year	For integrated cars	For components
1985	From 120% -- 150%	60%
1985.6	80% adjustment tax were added to the tariff above	
1986	180% - 220%	
1994	110% - 150%	50% - 80%
1996	110% - 120%	35% - 60%

Data source: Xia et al (2002)

Meanwhile, by production localisation, the share of FFEs grew very fast. More and more backbone SOEs joined in manufacturing imported car models by setting up JVs with MNCs. The share of FEEs in Chinese car market exceeded 60% in 1995 (see Table 4.5), while the share of direct imports decreased to under 40%. In the last ten years, the share of imports was definitely lower than 10%, usually below 5%, even though the absolute quantity still increased as in 2008 were 154,500 sets.

Table 4.7 Imports of completed car in China

Year	1985	1987	1989	1991	1993	1995	1996
Amount, set	105775	30536	45000	54409	181156	129196	57942
Market share, %	95.3	59.4	75.1	57	60.5	37	14.3

Data source: China Automotive Industry Yearbook, various years

The telecom-equipment sector was one of the industries that China had opened to international competition early. By doing so, policy-makers aimed to foster the building of telecom infrastructure, in pursuit of the relevant positive impact on the entire economy. For this reason, tariffs were kept low to promote the equipment imports. During 1980s -1990s, the import tariff was 12%, below that of most other imported products. As for deals entailing credits or loans from foreign governments or cross-country organisations, e.g. World Bank, Asia Development Bank, a special clause was offered to free the custom duties.

The low level tariff and the fast growing demands made China a hot market for MNCs to sell their products to. In order to encourage inward technological transfer and manufacturing localisation, at the end of the 1980s, China implemented an “infant industry protection” policy to protect the early stage Sino-foreign productive JVs against the dumping sales initiated by Japanese competitors. The protection policies included the special subsidies provided by the Chinese government for Group-A firms. As for import tariffs, a “tariff free for the first two years and deduction by half for the subsequent three years" treatment was offered for the component imports of productive JVs. Furthermore, in 1999, a bill named "*Interim Measures about Reducing and Exempting the Enterprise Income Tax for the Investment in Technological Renovation of Domestically Made Equipment*" was announced. This bill approved a reduction of the newly added income tax by the amount equal to 40% of the corresponding investment.

After 2001, China had to give up the above special treatments related to tariffs as response to the requirements of the WTO (World Trade Organisation). The import tariff of the automobile industry was cut down to 25% for integrated cars and 10% for components after 2001; as regards most telecom equipment products, the import tariff was almost zero.

(3) Other favourable treatments

Finally yet importantly, the Chinese government implemented a number of other favourable treatments in order to encourage SOEs to set up productive JVs with MNCs. Most of these treatments were based on case by case considerations and without any written rules to follow. However, these activities still shaped up some conventions.

First, in order to increase the success ratio, the government was inclined to encourage excellently performing SOEs to be partners of MNCs. Therefore, backbone SOEs, or regional backbone SOEs were preferred candidates for governments. Further, the governments would also allow SOEs to peel off non-performing assets to set up new entities to attract foreign partners. Good human resources, factory buildings, valued equipment and best business lines were allocated to JVs. Retired, old and weak personnel, debts and backward business lines were kept in old entities. From another perspective, it in practice added to the extensive difficulties of SOEs after the mid 1990s.

For many cases, good-performing resources were not only collected from local SOEs, but also mobilised by industrial ministries or state owned industrial groups from other places or other divisions. For example, regarding the case of Shanghai-Volkswagen, the major Chinese entity was appointed as the Shanghai Auto that had the largest domestic car production line at that time[30]. Additionally, the entire automobile industrial community in Shanghai was mobilised to listen to the demands for building up this JV. Regarding the case of Shanghai-Bell, MPT sent notices to all its affiliated firms[31], institutes and universities, and finally called on 150 S&T elites around its country-wide system to participate in the building of Shanghai-Bell. MPT even set up a bureau specially named the "*1240 Bureau*" to activate resources and provide support.

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[30] The "*Shanghai*" ("*Phoenix*" before 1964) model was produced by Shanghai Auto at that time with an output of 7000 sets per year, which was a local design developed in the 1950s that targeted *Benz-170*. Its production was stopped in 1991, because the factory facilities and human forces were asked to transfer to the building of Shanghai-Volkswagen.
[31] At that time, MPT directly and indirectly supervised more than 100 factories and over 65,000 personnel.

The especially favourable treatment that happened more frequently was the direct allocation of resources at free or very low cost to the JVs. The rights of using lands were often offered at very low fees or even freely to the JVs during appointed time periods (usually in decades). Low-interest loans were offered by local banks under the coordination of government. The services of training personnel and constructing infrastructure (facilities for road, harbour, other public transportation, water, energy, living-care, etc.) were also generally offered by governments for important JV projects, in addition to the governmental purchases made to support the business of JVs.

4.3.4 Summary

The birth and prevalence of the TMFT policy did not come from pure theoretical discussion, but from policy controversies based on developmental practices. The shortage of forex, the (seeming) shortcomings of other patterns and the transition of ideology worked jointly to generate a policy change of introducing foreign technologies inwards. The policy-makers was looking after a more "efficient", "low cost" and in fact highly packaged pattern of technological inward transfer. The TMFT emerged for its potential for bringing about something seemingly therapeutic, as follows: to set up JVs with MNCs that had advanced technologies[32] on hand could make use of foreign capital and import advanced technologies; the cooperation based on high packaged technological transfer could bring advanced product models; the problems about complementary capabilities were expected to be solved by introducing international suppliers of MNCs or by establishing complementary JVs locally; to have foreign collaborators was expected to enable domestic firms to learn from foreign collaborators closely, and to replace Chinese "backward" and rigid socialist corporate governance with advanced governance patterns. These expectations developed into the initial cognition of Group-A firms (see Table 4.8).

The TMFT framework in practice was buttressed by a series of favourable policy treatments. These treatments built the TMFT policy into a profitable business model to both the domestic side and the foreign side. Many SOEs looked forward to be involved in it, especially when they met difficulties in facing market competition. Moreover, rapid expansion of production capacities of most Group-A firms after setting up JVs also made it seem to be an "effective" model of "technological learning", and attracted more domestic followers to take the initiatives. For example, the negotiation to establish the FAW-Volkswagen JV was carried out spontaneously by the executives of FAW, which was not part of the plan of Chinese policy-makers at the time (Hahn,

[32] During the transitional process, "advanced technology" was an obscure concept for policy-makers because of their cognitive limitation. For their lack of experience in developing complex products and systems, mistakes were often made. In the 1980s and 1990s, "*importing outdated equipment/designs*" was often found on newspaper and governmental documents as criticism. In the power-equipment sector, China had the major part of XiYi, the former largest instrument factory in Asia, to set up a JV with Yokogawa of Japan. Only after that, Yokogawa was found to have no specific product of the digital control system for electricity equipment as what Chinese had assumed.

2005).

Table 4.8 Learning model of Group-A firms

Target	Technological learning and indigenous product development; import substitution
Detailed pattern	Having MNCs as partners and learning from them closely; following a bottom-up pathway
Business rewards	Economic incentives provided by the government; fast expansion of production capacity

4.4 Emergence of Group-B firms

The emergence of Group-B firms was the other side of the coin against TMFT framework. They grew independently from the orthodox governmental industrial administration -- none of them belonged to the governmental *GuiKou management* system to produce car or telecom- equipment before. In fact, the emergence or growth of Group-B firms was unexpected by the central planners. So Group-B firms were not supported by the government at least in their early stages. Relevantly, in their early stages, they were not welcomed by MNCs as TMFT partners too, since Group-B firms could not bring about those benefits for the JVs as mentioned above. For a long time, industrial policies had negative impacts on these new entrants since the policy-makers tried to protect the advantage of Group-A firms. That was to say, Group-B firms had to depend on themselves, which contributed to the shaping of their initial cognition and strategy.

Compared with Group-A firms, Group-B firms carried out a different pattern of technological learning. Their learning was not implemented through establishing JVs with MNCs, but through in-house product development and industrialisation. Group-B firms did not rely on specific JV partners, but they also made use of technological resources globally. Group-B firms started their businesses under tough market competition, which was not only by foreign rivals but also domestic incumbents, including Group-A firms.

4.4.1 Origins of Group-B firms

4.4.1.1 Telecom-equipment sector

Most of the telecom-equipment Group-B firms were established during the second half of 1980s and the first half of 1990s, as listed in Table 4.9.

Table 4.9 Basic info on Group-B telecom-equipment firms

Firm	Est year	First product model	Ownership	
			Start-up stage	Current stage
ZTE	1985	Low-end analog switch	Spin-off from a military SOE	Listed, about 40% held by SOEs
Huawei	1988	Low-end analog switch	Private firm	collectively-owned mainly; mixed-ownership
DTT	1993	Large scale PDSS	Reformed from governmental institutes	Mixed-ownership, listed firm, dominated held by SASAC
GDT	1995	Large scale PDSS	JV by 8 MOEs and 1 military institute	Mixed-ownership, dominated by a SOE
Xinwei	1995	Technical standard of mobile telecom	Mixed ownership; 44% held by DTT	Ibid; ready to be listed

Among Group-B firms, there were governmental elements in the establishment of DTT and GDT. But these two firms did not belong to the orthodox plan of government for the development of telecom-equipment industry.

The DTT (Datang Telecom Tech.) was reconstructed from governmental research institutes and a section of the Academy of Telecoms Technologies division within the MPT system. Even today, DTT is still called the “China Academy of Telecom Tech (CATT)”. Meanwhile, it is also owned by the SASAC as one of the central government-owned firms. This arrangement is termed “*One institute two mandates (YiGe ShiTi LiangKuai PaiZi)*”. This means in a certain research institute two operational rules coexist with each other: one is academic and the other commercial (Gu and Lundvall, 2006, p302). It is a particular phenomenon for the transitional industrial S&T system in China. DTT can be regarded as a competitive industrial group, by which it has to be responsible for its own benefit-making. Meanwhile, CATT retains partial functions of a public institute. So it is continuously required to provide industrial technological services, for which limited governmental appropriation is offered.

The GDT was a JV established by CIT[33] and eight MOEs. As a company, GDT was built in 1995, but its core product and technology had been developed by CIT from the mid 1980s on. The *HJD-04*, namely its core product model, was launched in 1991, which was the first indigenous large-scale PDSS in China[34]. The PTIC (China Posts and Telecom Industrial Co) and the LTEP (Luoyang Telephone Equipment Plant)[35] provided assistance in finance and experimental facilities during the development of *HJD-04*, and they set up an alliance with CIT to produce the *HJD* series before GDT was formally established. Hereafter, by referring to GDT in this thesis, we include both the alliance before 1995 and the industrial group after that.

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[33] CIT is a military S&T unit, namely the Centre of Information Tech. at Zhengzhou Institute of Information Engineering of the People’s Liberation Army.

[34] In the contexts of China’s telecom-equipment sector, switch was called as “large scale” if it could provide more than 10,000 lines of communication with one set of equipment.

[35] PTIC was the orthodox industrial group of MPT as equipment provider, and the supervising agent of affiliated MOEs. LTEP was an affiliated MOE to PTIC.

Besides the above two, Xinwei was jointly established by DTT and CWiLL (an American start-up firm held by a group of overseas Chinese scientists). As for Huawei and ZTE, detailed introduction will be made in the respective case studies.

4.4.1.2 Car-making sector

Table 4.10 Basic information on Group-B car-making firms

Firm	Year founded	First product model	Ownership	
			Start-up stage	Current stage (2009)
HaFei	1984	One design for minibus	Newly established division of a SOE	Incorporated with another SOE, listed
Chery	1997	One design for an engine, one design for a sedan	SOE	SOE, mixed held
Geely	1997	One design for hatchback	Private company	Private firm, listed
Brilliant	1991	One design of MPV	Mixed ownership	Mixed, listed
ChangAn	1984	One design of minibus	SOE	Mixed, dominated by SOE, listed

No car-making Group-B firms were MOEs of the ministry in charge of the automobile industry. Chery and Geely represented over 100 new entrants entering this sector during the late 1990s and early 2000s that had no support or permission from the government prior to 2001. They were owned in different forms. The firms of this kind included the GreatWall, BYD, GoNow, ZhongTai, LiFan, etc.

HaFei and ChangAn represented another group of firms. They were MOEs. Nevertheless, they were not affiliated to the ministry that exactly supervised the automobile industry[36]. These firms, including the YunQue, ChangHe, ChangFeng, etc., entered the automobile industry in the 1980s. Their entries were supported by industrial policies of encouraging the conversion of military technologies into civil products, which were made under the pressure of lowering the growth of military expenditures beginning in the early 1980s[37]. As an outcome of coordination at the ministerial level, these firms were allowed to produce marginal products in civil markets, mainly minibuses and mini-trucks.

Brilliant was a representative of former SOEs held by the regional government. After two decades of reform, most of them were based on mixed-ownership. Before 2001, they had been licensed to produce automobile but with the exception of cars. Thus, before entering the car-making sector, they produced other automotive products, e.g. trucks, MPVs or specific-use vehicles.

[36] HaFei was held by the MOAI while ChangAn was held by the Ministry of Weapon Industry.

[37] It was for the cease of direct contradiction between China and the capitalist camp by the end of the 1970s, and with USSR since 1984. After these changes, many military projects were given up, or their budgets were cut down.

4.4.2 Impact of national institutional change on strategies of Group-B firms

Being different from its bottom-up reform of the agriculture sector, China's reform in the industrial sector mainly followed a top-down mode. The reform of the industrial system was led by policy- makers and society elites, although some industrial practitioners jumped the gun from time to time. Therefore, as to Group-B firms, legacies of central planning system brought them difficulties in their infancy since they were outsiders to the *GuiKou Management* system. Consequently, they were also not welcomed by MNCs as potential TMFT partners because they could not provide the benefits of the TMFT business model. The contextual conditions brought about the particular views of Group-B firms on technological learning patterns, and induced their strategy-making of learning.

4.4.2.1 Car-making sector

In the car-making sector, there were two licensing regulation systems, one for domestic firms and one for foreign investment, both of which placed Group-B firms in a disadvantageous position.

(1) Regulation for domestic firms

Before 2001, it was necessary for firms to get licence for every model of theirs, either imported or locally developed, before corresponding models were launched on the domestic market. It was called "*MuLu GuanLi*" *(Catalogue Management)*, since all newly approved models would be listed by regulators periodically in a catalogue. For example, in Shanghai-Volkswagen, there were 9 licences for the "*Passat"* series (data from April 2007) imported from Volkswagen. This was because there were technical dissimilarities with regard to important details (such as engines or gearboxes adopted) for these 9 versions of the "*Passat*".

Even though the licence regulation stressed product models, it in fact was a barrier to industry entry. Once firms had already been listed as automobile manufacturing firms, licence regulation for specific models was a technical inspection method. On the contrary, if firms were not accepted by regulators as automobile producers, they would be kept far from the catalogue in spite of anything in the technical dimension. Such a system was the legacy of the former command economy in industrial entry administration, by which policy-makers aimed to bring about national champions by providing them the market protection.

Before 2001, only FAW, DongFeng, SAIC, Guangzhou Auto and Nanjing Auto were allowed to produce cars, i.e. the sedans, hatchbacks and estate cars. Among these five, the former three were called the "*Big Three*" of the Chinese car-making sector, which implied their significance in the scheme of central planners; they were really the three largest automobile manufacturers of China during most of the past decades. Even today, they are still the core players in the Chinese automobile industry.

In addition to the five above, Beijing Auto was allowed to produce jeeps and pick-ups. Beijing Auto and the above five were owned by the ministry in charge of the automobile industry. Therefore, they were called the "*Six Bigs*" in the car-making sector, referring to their orthodoxy within the industrial administration[38]. By regulators before 2001, only the "S*ix Bigs plus Three Minis" (6+3)* were supported by the central government[39]. The "*Three Minis*" were HaFei[40], ChangAn and Tianjin Automobile, which were allowed to produce marginal passenger car products, namely mini-cars or mini-buses. The permissions were provided at the request of military division and regional governments in order to improve their economic situation.

Table 4.11 Production licence system of the car-making sector (before 2001)

Products licensed (amount of firms)	Firms
General cars (5)	"*Big Three*": FAW, DongFeng and SAIC
	Others: Nanjing and Guangzhou
Jeeps and Pick-ups (1)	Beijing
Mini-cars or Mini-buses (3)	HaFei, ChangAn and Tianjin

Note: HaFei and ChangAn were licensed to produce mini-buses but not mini-cars; Tianjin Auto was licensed to produce mini-cars.

The regulation system of production licensing was finally changed in 2001. The regulation examinations prior to production were removed, to be replaced with an authorisation system posterior to the product launch. This meant that firms could apply to regulators initiatively after 2001. Product models would be authorised if passing the technical and investment requirements. This change gradually permitted a series of firms to enter the car-making sector, including all the Group-B firms in our study.

(2) Regulation for foreign investments

The regulation for foreign investments in the car-making sector remains even today. This can be summarised with two rules. Firstly, MNCs have to cooperate with Chinese firms if they want to establish productive firms in China; secondly, the maximum amount of productive JVs they can establish is two. For example, since Toyota had already built up productive JVs with Tianjin Auto and Guangzhou Auto, it could not establish a third one with FAW until FAW merged Tianjin Auto in 2002.

The regulation regarding foreign investments was permitted as an extra clause of the agreement between China and the WTO. It was designed to protect the indigenous automobile industry and to oblige MNCs by concentrating on technological transfer – if it did exist in an effective way. It in fact gave advantages to backbone SOEs for their negotiations with MNCs, since MNCs only

[38] In the era of command economy, Nanjing Auto, Guangzhou Auto and Beijing Auto were jointly owned by ministry and regional government.
[39] Actually, the structure of car sector kept evolving even under the central planning system, which represented the competition of industrial and policy resources among ministries, and between central and regional governments.
[40] In early days, HaFei and ChangHe used the same licence since they belonged to the same ministry.

had limited choices in number of local partners for both the limitation of regulation and the limited choices of competent candidates. Some backbone SOEs consequently had different JVs with more than one MNC. For example, FAW had JVs with Audi (Volkswagen), Volkswagen and Toyota, as well as non-entity cooperative production with Mazda (Ford); DongFeng had JVs with Citroën (PSA), Honda, Nissan (Renault), and Kia (Hyundai); SAIC has JVs with GM and Volkswagen; Guangzhou Auto has JVs with Toyota and Honda; and Beijing Auto has JVs with AMC (Chrysler), Chrysler, Daimler-Benz and Hyundai.

Apparently, with such a regulation, MNCs would not choose Group-B firms as their local collaborators when Group-B firms were in their infancy and did not recieve the equitable treatment from the Chinese government.

4.4.2.2 Telecom-equipment sector

As mentioned, the telecom-equipment sector was one of the sectors opened to international competition early in the 1980s. Then the industrial regulation mainly focused on the technical dimension, and few other rules were set to prevent the entry of imported products or domestic providers. However, since the regulators, the SOE equipment providers and the telecom-operators all derived from the former MPT system, Group-A firms had the orthodox kinship with the regulators and telecom-operators. They had also been embedded in the existing mainstream value networks. All these apparently brought Group-B firms an advantage over newcomers. On the contrary, Group-B firms were difficult to win the favour from the regulators and telecom-operators in their early phase; they were regarded as outsiders.

The case of *HJD-04* illustrated the invisible barriers well. The *HJD-04* was the first indigenous large-scale industrialised PDSS model in China with a significant technological contribution to the entire domestic or even the global industrial community at that time. It was developed by the CIT, an outsider to the MPT system. During the development of *HJD-04*, the PTIC and the LTEP offered assistance to the CIT[41].

However, even with the assistance of PTIC, MPT still denied the application of *HJD-04* for the official technical approval in 1991, which was necessary for any equipment model to be installed on the Chinese telecom-network. The nominal reason that MPT gave was that CIT had not applied for an approval for this project beforehand, which was indeed just an administrative rule under reform. In fact, it was because, firstly, the officials and technical experts of MPT recognised the *HJD-04* as “computer system” rather than a telecom system in the mid-term official examination for the *HJD-04* in 1989. Such an opinion in fact reflected the cognitive limitations of relevant

[41] PTIC allocated 3 million RMB to CIT for its development of *HJD-04*. CIT itself invested 0.15 million RMB, which was borrowed from the Institute of Information Engineering of the People’s Liberation Army and was the total investment used by CIT to develop *HJD-04* before getting the aid from PTIC.

examiners deeply rooted in an ideology grounded on the branch-based industrial ministry system. Ironically, even the PTIC, namely the major financial sponsor of this project, ever stopped its aids for CIT in 1988 for the same query. Secondly, even though PTIC was the orthodox industrial group of telecom-equipment affiliated to MPT, the PTIC was officially appointed to the manufacturing division, not the R&D division. Therefore, what PTIC did in fact crossed the red-line and violated the norm within the MPT system, which was certainly not welcomed. Thirdly, MPT felt unhappy that its industrial scheme was challenged by a domestic outsider. By 1991, MPT had already had three Sino-foreign productive JVs established by MOEs under the TMFT framework. Meanwhile, the research division of MPT had already carried out several product development projects, including the *DS-30* and the *DS-2000* as key projects. Therefore, the emergence of *HJD-04* actually became a challenge to MPT's learning schemes[42].

Finally, the problem between *HJD-04* and MPT was solved only after the involvement of the top authority of the military and the Chairman of China[43]. These leaders took the *HJD-04* as an important example of appropriating military technologies for civilian uses, which was a national theme of that period. MPT had to arrange a technical examination for *HJD-04* by the end of 1991. Nevertheless, it still organised a very "hostile" committee – major members of the committee were all potential rivals or victims of the *HJD-04*'s potential success, namely people from the orthodox research divisions and from Sino-foreign JVs. Even after *HJD-04* had proven to be a model advanced in technology and convenient for industrialisation, MPT still compelled two executive managers of PTIC to retire ahead of their normal schedules, as a punishment for their offence to the industrial ministry system.

4.4.3 Summary

In the early phases of Group-B firms, Chinese policy-makers had not regarded them as competent candidates to realise effective technological learning. They were excluded from the TMFT framework by both policy-makers and MNCs[44]. We summarise the reasons as follows:

Firstly, as new entrants, Group-B firms had not the same market power as the incumbent SOEs.

Secondly, Group-B firms were unable to obtain production licences in the car-making sector. As for the telecom-equipment sector, Group-B firms did not have close relationships with the

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[42] In fact, *HJD-04*'s success did bring about disruption to the MPT system not only in terms of technology. After *HJD-04* was identified as a PDSS model with different but outstanding technical features, the R&D funds allocated from the SPC to the No.1 and No. 10 research institutes of MPT for the *DS* series projects were significantly decreased. So, it is not difficult to understand the hostile opinion of MPT regarding such a challenge as an *ex post* test.

[43] ShangKun Yang was the Chairman of China at that time. As a revolutionist before 1949, he had intimate relationship with the military.

[44] Before 2001, some Sino-foreign JVs had been built by military-background SOEs with MNCs. These SOEs were picked because of the limited choice of MNCs according to the regulation and because of the coordination of government. These JVs produced mini-bus, mini-car or MPV, according to licences they had. For example, ChangAn co-operated with Suzuki to produce small size hatchback (but in name of "minibus" for the licence) from 1995 on.

industrial regulators, customers or even component suppliers. There were other policies discriminatory to these non-orthodox firms[45]. All of these made Group-B firms outsiders to the existing political-economic industrial value networks.

Therefore, Group-B firms could not provide economic incentives to MNCs in the ways that Group-A firms did. Most of them did not get support from governments with incentive policy packages. Several of them were supported by regional governments, such as Chery, HaFei and DTT, but the packages even in case the regional governments would provide them were not attractive enough to MNCs compared with the prevalent TMFT framework.

Only when Group-B firms had formally entered the corresponding sectors and proven their potential by market competitiveness, did MNCs make proposals to establish productive JVs with them[46].

Thereby, Group-B firms were induced to focus on in-house capability building if they wanted to develop systemic products. Throughout the independent development of products, they selected and built up their own organisational systems, which created fundamental differences between those of the Group-A firms.

4.5 Industrial background: performance comparison

In the past over two decades, Group-A firms have achieved the steady growth of production capacities. However, Group-B firms have begun challenging incumbents at a fast rate of growth. If considering the new product development, they shape a sharp contrast against the Group-A firms: Group-B firms act aggressively in developing new products while Group-A firms contribute little.

4.5.1 Production capacity

Many Group-A firms enjoyed a steady growth of production capacity under the TMFT framework. In the car-making sector, the production of cars equalled more than 600,000 sets in 2000, namely the year before new entrants were officially allowed, producing a sharp contrast with only 4,000 sets in 1982, namely the year before the setup of the first Sino-foreign productive JV.

Starting from 2005 and 2006 respectively, SAIC and FAW became listed in Fortune 500[47], and

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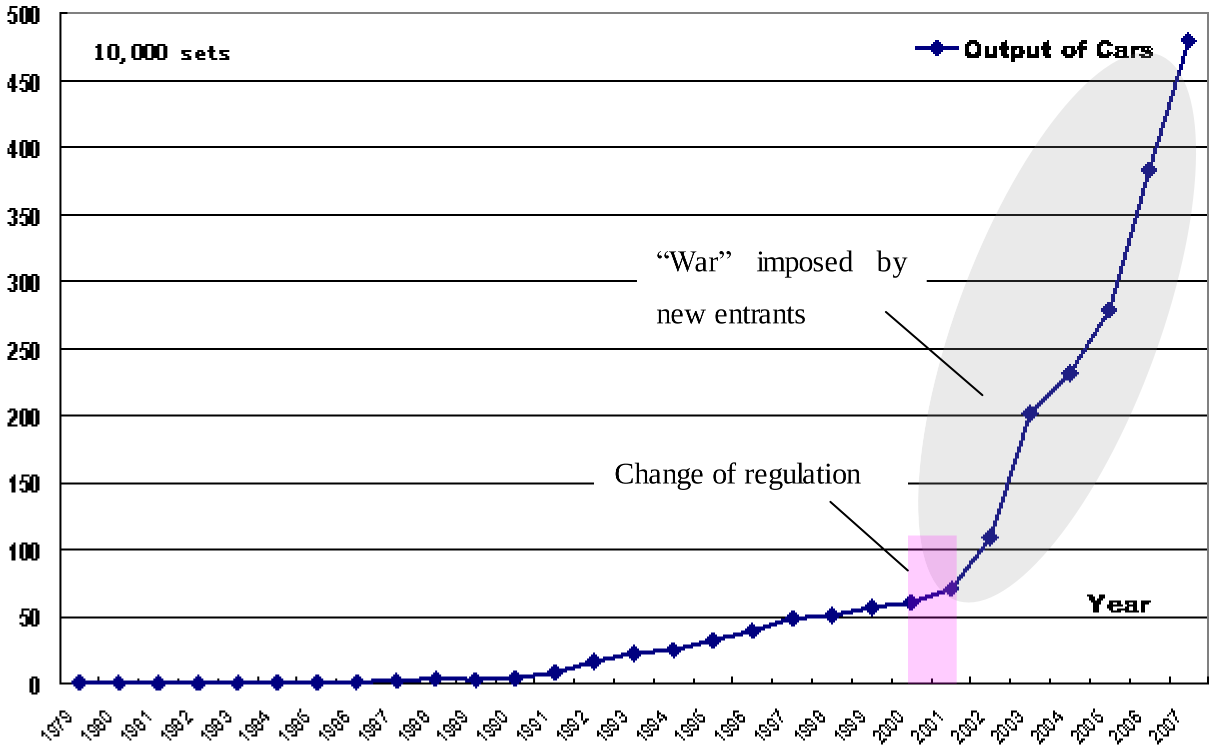
[45] For example, in the car-making sector, Group-A firms could import sample cars or subsystems from overseas with very low duties and quickly in the name of "sample products", whereas Group-B firms, since they were without official support, had to go through the procedure and pay as much as for consuming imports.

[46] For example, after ChangAn had already got the licence for car-making and presented good performance in mini-bus segment, it established a JV with Ford in 2001. The JV between Brilliant and BMW was set up in 2002 when Brilliant had accumulated comparative resources and competence in manufacturing MPVs. HaFei denied the proposals from Mitsubishi to establish JV twice. Chery denied the proposal from GM. GM suggested a JV when it found that the economic-compact models of Chery successfully overwhelmed its former Daewoo models in the Chinese market.

[47] FAW had not applied to be assessed by the Fortune before 2006.

ranked 373 and 303 in 2008. In general, Group-A firms had leading roles in the fast growing domestic market, by which the TMFT policy did realise its target for import substitution. Among the JVs set up by large MOEs, only the Guangzhou-Peugeot and Nanjing-Fiat ever met with fundamental failure. Peugeot quit the Guangzhou-Peugeot for the continuous financial loss, and sold its share at one Franc to the Chinese side in 1997. Feeling unsatisfactory with the performance, Fiat also quit the JV with Nanjing Auto in December 2007. Additionally, Fuji Heavy quit from the Fuji Heavy-GuizhouYunQue in 2002, but it was in the minicar segment.

Figure 4.2 Evolution of the Chinese Car-making Industry



Source: China Automotive Industry Yearbook (2008)

In the telecom-equipment sector, the TMFT policy led to the emergences of a series of "star enterprises", including Nanjing-Ericsson, Beijing-International, and Qingdao-Lucent. Shanghai-Bell was the top one among them. From 2000 on, Shanghai-Bell became the largest provider of telecom switches in the whole world. In 2000, its new-sales of all kinds of switches were 10.79 million lines. Up until 2002, there had been 78 million lines of *S1240* (the first product Shanghai-Bell imported from BTM) installed on the Chinese telecom network. It dominated the high-end market of PDSS (C1-C2[48]), with a market share of over 95%.

On the other hand, as newcomers, Group-B firms realised even faster growth rates than Group-A

[48] China's telecom network comprises C1-C5 layers, as a pyramid in quantity, but is reverse in unit price and significance. C1 is at the top, referring to the layer of national telecom exchangers. C2 is at the provincial layer.

firms ever did. They started their business from serving market segments to which Group-A firms and foreign firms seldom paid attention. Gradually, they grew to attack the mainstream market.

In the car-making sector, Group-B firms had been insistently promoting the striking expansion of the Chinese car market since 2001. They provided more choices of car models for customers by their capabilities of product development, especially for the low-priced or economic-compact cars. With the rapid growth of Group-B firms, and the competition introduced by them, China's automobile industry has been growing at a stunning speed since 2001. In 2009, the Chinese automobile production and market size went beyond those of the United States and Japan, ranking No.1 in the world by 13.8 and 13.6 million sets respectively. The fast expansion of the Chinese automobile industry should be due to the growth of Group-A firms, but particularly to the emergence of Group-B firms after 2001, which changed the industry totally (see table below).

Table 4.12 Share of indigenous brands in domestic car-making market (2001-2008)

Year	2001	…	2004	2005	2006	2007	2008	2009 (first half)
Share	<5%	—	20.60%	24.67%	25.67%	26%	25.92%	45.32%
sets			462,500	692,029	982,800	1,242,200	1,308,200	2,054,900

Source: China Association of Automobile Manufacturers and HongYueXinSi Consultant.
Note: The share is calculated by sets of cars. The statistics on "indigenous brands" include brands based on imported technologies, e.g. XiaLi and RedFlag.

Among Group-B firms, Chery entered the list of top-10 car-makers in the Chinese domestic market from 2002 onward, namely from the second year it was officially allowed to enter this sector. Geely that occupied the Volvo in 2010 starting from 2005 and BYD from 2009 firmly held their positions in the top-10. The *F3* model of BYD became the No.1 model as of October 2008 in terms of sales in the Chinese car market, which was sustained until the 1st quarter of 2009. Besides, HaFei, Brilliant, and ChangAn[49] were very competitive candidates for the top-10 in recent years; GreatWall, ZhongXing, GoNow and LiFan also grew rapidly.

Besides, Group-B firms were no doubt the major force of car exports. Chery led the exports from 2002 onwards. Its exports, by completed car, CKD and SKD kits, were 119,800 sets in 2007, occupying a significant share of the total Chinese automobile exports of that year at 590,000 sets, which included the statistics for the exports of cars, trucks and other civil vehicles. In 2008, its exports were about 140,000 sets.

However, as regards the processing technologies, Group-A firms still had general advantages. For example, to finish the welding tasks for one car body-in-white in Guangzhou-Honda needed 45 seconds on average. For Chery, to finish the welding tasks required 180 seconds for one *Fulwin*, 180 seconds for one *QQ*, and 240 seconds for one *Eastar*; the best team of Chery could finish welding a car body in 130 seconds (data from 2006). But it was obviously less efficient by

[49] A Sino-foreign JV of ChangAn's is in the top-10 in 2007 and 2008, namely ChangAn-Ford-Mazda.

comparison with that of the Guangzhou-Honda.

For the the telecom-equipment sector, Group-B firms had surpassed Group-A firms in general. In their early phases, the development of Group-B firms had lowered the prices of equipment significantly. Regarding the PDSS in the mainstream domestic market, the average price in the 1980s was 1500–3000 RMB/line, which was cut to 600 RMB/line by the early 1990s. In the late 1990s, the price of imported products was further depressed to 300-600 RMB/line. Indeed, confronted with the tough competition raised by indigenous firms, MNCs even had to implement dumping strategy to maintain their previous market advantage, especially for some initial instalment markets[50]. Fujitsu was notorious in the late 1990s for dumping its PDSS at the price of 15-25 RMB/line. In spite of that, the share of indigenous PDSS products still rose steadily: it was 10.6% in 1992, and went beyond 60% in 1998 after the price war of PDSS during 1995-1998.

Table 4.13 demonstrates the domestic telecom-equipment firms included in the annual “top-100 ICT manufacturing firms of China”. This table indicates the catching-up process of Group-B firms with their domestic competitors. Because of the rapid growth of Group-B firms, the market shares of many Group-A firms in the Chinese market had been squashed. Even for the global competition, according to the statistics of Dell’Oro, in the first three quarters of 2009, Huawei had occupied 20% of the global market, ranked No.2 in the world only after Ericsson. ZTE occupied 5% of the global market in 2008.

[50] The initial market is very important in the telecom equipment market, since providers can benefit from further procurement of customers based on the existing network.

Table 4.13 Rank of telecom-equipment firms in the "top-100 domestic ICT manufacturing firms list" of China (modified)

Year	Group-A firms		Group-B firms
	Sino-foreign JVs	SOEs	
1986-1991	N/A	N/A	N/A
1992	Shanghai-Bell [5] Beijing-Siemens [73]	Hangzhou [36]	(GDT)
1995	Shanghai-Bell [7] Beijing-Siemens [33]	Hangzhou [12] Shanghai [55] Nanjing [83] Shanghai Wireless [90] Luoyang [91] Chongqing [95]	Huawei [26] (GDT)
2000	Shanghai-Bell [12] Nanjing-Ericsson [13] Beijing-Siemens [32]	PTIC [1] Guangzhou PT [79]	Huawei [8] ZTE [22] DTT [36] JinPeng [61]
2006	Alcatel-Shanghai-Bell [15] Nanjing-Ericsson [23]	PTIC [13]	Huawei [3] ZTE [11] WRI [58] DTT [91]
2007	Alcatel-Shanghai-Bell [10] Nanjing-Ericsson [18]	PTIC [21] Jiangxi [79]	Huawei [1] ZTE [4] WRI [50] DTT [84]

Note: The numbers in brackets are the ranks of corresponding firms on the top-100 ICT firms list; the ranking is done annually by the government according to a synthesis calculation of business revenue and profits. The ranks of PTIC in 2006 and 2007 are calculated by the author since it denied to be evaluated by this list. The ranks of GDT before 1995 are calculated by the author; GDT had not been established as a company formally before 1995, but relevant SOEs in this table had been producing HJD series products developed by CIT.

4.5.2 New product development

In spite of the general production capacity growth of Group-A firms and Group-B firms, there is a sharp contrast in the domain of new product development between these two groups of firms.

In the car-making sector, only DongFeng among Group-A firms had developed a systemic car model by 1996. That model was finally launched and produced at small scale only. By contrast, the frequency of new product launches of Group-B firms was maintained at high rates after 2001.

In the telecom-equipment sector, there had been no new systemic product launched by Group-A firms during the past two decades. Many Group-A firms just continually imported product models from foreign partners. Only a few of them established the capabilities to provide network solutions for customers based on products they manufactured. For example, Shanghai-Bell and Nanjing-Ericsson were able to produce full series of products of landline telecom, 2G (second generation) and 3G (third generation) mobile systems, digital data transmission, etc. Worth mentioning technological development in Shanghai-Bell, as the top performing Group-A firm, were two product modules it developed locally in the 1990s. Some other JVs even continued to produce the same products as they had been producing from the very beginning on.

Group-B firms all demonstrate aggressiveness in new product development. Huawei and ZTE had developed their own full series of telecom products and key components that were generally produced by international frontier equipment providers. DTT and Xinwei had their capabilities in developing frontier technical systems. From 1998, they had developed the technical standards of a mobile telecom system that finally became the SCDMA and TD-SCDMA. Based on these technical standards, the full series of equipment had been developed, and industrial alliances were set up to shape the value networks. SCDMA was the first indigenous mobile telecom standard that had been developed with over 10 million installed lines. The R5 version of SCDMA, i.e. the McWill, with official support from Chinese government for its excellent technical performance, became a competitive rival for WiMax. TD-SCDMA had been considered as one of the ITU (International Telecommunication Union) standards for 3G mobile telecoms, and began mass commercialisation in 2008. By June 2010, the network of TD-SCDMA provided services for over 10 million subscribers in China, and the scale continued to expand.

The comparison between Group-A and Group-B firms with regard to new product development is demonstrated in Table 4.14.

Table 4.14 The performance of developing new products (before 2006)

Group	Firms	No. of new systemic products developed	Other products developed
G-A car	FAW	0	3 car bodyworks partly remodelled based on imported models
	DongFeng	1	1 car bodywork partly remodelled based on imported model
	SAIC	0	4 car bodyworks partly remodelled based on imported models
G-A tele-eqmt	Shanghai-Bell	0	2 specific-purpose modules developed
	Jiangsu-Fujitsu	0	NA
G-B car	Chery	7	Relevant core components and assemblies
	Geely	9	Relevant core components and assemblies
	HaFei	4	1 car model based on re-engineering of imported model
G-B tele-eqmt	Huawei	Full sets equipment for telecom	relevant handsets, supportive technical standards
	ZTE	Full sets equipment for telecom	relevant handsets, supportive technical standards
	DTT	TD-SCDMA standard; Full-set equipment	relevant handsets, supportive technical standards
	Xinwei	SCDMA standard (4 generations); Full-set equipment	relevant handsets

4.6 Summary

In this chapter, by briefly going through some key points of the Chinese reforms, we have aimed to give a picture of the sources, the learning patterns and the performances of the two groups of domestic firms that we study.

The TMFT policy was generated to fulfil the expectations of the Chinese for a method of transferring technologies inward with high efficiency and low cost. The seeming weaknesses of other patterns of technology import, the financial status and the political change drove policy-makers to look for highly packaged technological transfer methods. The TMFT policy came as a solution, by having the backbone SOEs establish productive JVs with MNCs. Two targets were emphasized together, namely to realise import substitution and technological catching-up.

Many backbone SOEs were involved in the TMFT policy. They followed this policy not only because they were influenced by industrial ministries, but also because the legacy of the central planning system brought them the poor experience in organising the development of complicated products. Particularly when Group-A firms perceived the apparent gap of technological capabilities between them and international giant firms, they felt unconfident in the face of international competition and felt hungry for assistance from the MNCs.

A series of supportive policies was set up by Chinese central government to underpin the TMFT practices. Moreover, regional governments distorted the prices of critical factors to encourage the establishment of Sino-foreign JVs, including the use of land, the factory buildings, the human resources, the infrastructures and the soft loans. These supportive policies and special incentive packages provided by government in fact shaped TMFT into a likely profitable business model. The view of Group-A firms on learning and then their learning patterns were shaped during this course. The orthodoxy and the benefits from the expansion of production capacities convinced many industrial practitioners that the TMFT framework was an effective pattern.

Concerning the impacts of TMFT policy that they received, the Group-B firms were the cases contrary to the Group-A firms. Group-B firms grew outside of the orthodox industrial system of central planning system. Their status of being newcomers and their lack of governmental support made them barely attractive to MNCs as TMFT collaborators. This induced some new indigenous firms to implement independent strategies of learning if they wanted to develop products in-house in spite of unfavourable external conditions. These firms became Group-B firms.

Both Group-A firms and Group-B firms had achieved significant growth of production capacity. As incumbents of Chinese industries, Group-A firms continued leading the industries before they were confronted with challenges from new entrants. Some Group-B firms had realised even faster growth rates, and came to challenge or surpassed the incumbents. Moreover, they demonstrated aggressive performances in developing new products, which established their market success, and overwhelmed the progress of Group-A firms in terms of product technologies.

Returning to our theoretical discussion in Chapter 2, this sharp difference between these two groups of firms in technological capability building cannot be explained by resource-based elements, e.g. the governmental support, the human resources, the financial status, the foreign partners, the equipment and production methods and even the market shares in their early phases. It is imperative for us to explore the difference of their learning patterns and find out where their differences of technological learning reside.

Chapter 5. Comparison: developmental activities and strategic intent

5.1 Introduction

From this chapter, our focus is on the comparison of learning patterns between these two groups of firms. We aim to explore the black-boxes of their organisations. Certainly, not all organisational dimensions can be analysed in this thesis. What we do is to highlight the important features that possibly result in the differences of their technological learning performances. The major theoretical concern is whether the organisational system plays a significant role in the process of technological learning.

In order to explore the relations between the organisational system and the process of technological learning, we adopt the concept of "*product development platform*" to frame our empirical studies. According to F. Lu (2007), the product development platform is a dynamic system that comprises R&D teams, product sequences, technical support systems, and experience and knowledge that take product development as their major purpose. Similarly, Fleck (2000) suggests that the platform is the coupling of product and activity; and Helfat and Raubitschek (2000) postulate that the development of the product development platform involves a co-evolution of knowledge, capabilities and products. In this thesis, three elements are included in the "*product development platform*", as follows. (i) The organisation works as the carrier of technologies and as the developer of products through organising and executing a continuity of developmental activities, and the organisation also embeds the relevant organisational knowledge of organising and executing correspondingly. (ii) The technology is the medium for the exploitation of capabilities of organisations, and is also the materialised knowledge to be used or outsourced to create the product. (iii) The product embodies in logical requirements and physical vehicles for the interaction between organisation and technology, and is also the economic output of this platform. Besides, the interactions of all these elements are taking place on a continuity of developmental activities.

In this thesis, the term "platform" is also adopted for "product platform", particularly for the analysis of the car-making sector. The "product platform" refers to a comparatively stable system to underpin a product family. The stable system consists of a series of subsystems, including the frame of the car, engine, transmission, suspension, driveshaft, differential, etc. Within a product platform, the architecture and designing logics for integrating these subsystems are kept stable, which does not deny incremental changes or multiple choices of each subsystem. For upgrading the product generations, the product platform can be changed as a whole. However, the changes of each subsystem would follow some designing principles that characterise the product family. Front-line practitioners in the automobile industry usually use the term "chassis" in a broad sense when referring to the product platform.

In our research, we take the “product platform” as a coupling of product and corresponding technological requirements. In other words, it is the materialised object of the “product development platform”.

The product platform is an expensive target to develop in terms of both financial cost and time consumed. It is also difficult to learn from external sources, since it embodies the logics of integrating of multiple subsystems, relevant technical skills and trade-offs to realise the building of system. For the complexity of these relations, some design logics are not demonstrated in blueprints, and hardly possible for learners to reproduce in an exact way through reverse-engineering. These invisible logics include at least two kinds: the trade-off among different subsystems and the impact assessment of component diversification at system level. We emphasize these because the term “product platform” is often used by industrial practitioners to measure the depth of technological exploration. Usually, the practitioners in the Chinese automobile industry classify the product development activities into five categories: (i) adjusting parts and decorations, (ii) adjusting the interior accessories, exterior accessories and bodyworks, (iii) developing new bodyworks, (iv) upgrading subsystems of chassis and (v) developing new platforms. Only the latter two entail substantial knowledge about product platforms. In our study, as regards the lack of in-house systemic product development activities, Group-A firms do not own product platforms although they can buy chassis subsystems or particular models from overseas. By contrast, Group-B firms are continuously investing in building up their product platforms.

Another term we will use as a core concept in this thesis is the “organisational learning system” or “organisational system”, as defined in Chapter 3 (see Section 3.1.2). It is the organisational dimension of the product development platform. By comparison with the orthodox governance issues, namely structure, control and process, we have resource allocation and application at centre stage to study technological learning. In DCs, the shaping of resource allocation and application pattern is also an evolutionary process comprising learning, selecting and building essences. Therefore, we highlight “strategic intent” and relevantly the “authority over resource allocation” to study the organisational structure, resource control and allocation. We adopt the concept of “institutional arrangements of organisational mobilisation and learning integration” to study organisational control and application of resources for learning. The “facilities and institutions for knowledge accumulation” are explored from the knowledge side to examine the connections between consuming resource and obtaining knowledge, and examine the connections between the individual and the collective in generating, accumulating and sharing knowledge.

In the following two chapters, we will compare the organisational learning systems of these two groups of firms. In this chapter, the focus is the developmental activities that provide the empirical foundation for analysing, and the strategic intent.

As mentioned, the TMFT policy had the target of building indigenous technological capabilities as well as import substitution. However, such a target of capability-building had not been really insisted on by Group-A firms in the long run. Even though the decision-makers of Group-A firms had not altered their long-term ambitions intentionally, they never implemented a full set of in-house product development activities for generating systemic understanding of products and relevant complex technologies. Rather, they stressed imitating the predetermined blueprints from their foreign partners. Multiple factors will be quoted for their deviation from original intent. Even without direct measurement of strategic intent, we still can state, according to their decade-long activities, that Group-A firms had been captured by the business model based merely on the extension of production capacity, and had been dependent on imported technologies. By contrast, Group-B firms insisted on their intent of indigenous product development, and their commercial successes did prove this strategy was feasible and sustainable. Even though Group-B firms also made use of foreign technologies, they had gradually built up complete sets of developmental activities, which were taken as the core of their product development platform and to support their knowledge acquisition from various sources.

5.2 Strategic intent and developmental activities of Group-A firms

As previously mentioned, along with the Chinese reform, SOEs gradually obtained managerial autonomy. The autonomy for operational management came first, and then the autonomy for general strategy making. However, Group-A firms were still inclined to listen to industrial ministries. The reasons were multi-fold. In addition to the ownership linkage, the lack of experience in independently carrying out the development of complex products and technologies was essential. The lack of experience and then confidence was also mirrored in their cooperation with MNCs: relying on experienced foreign partners apparently sounded conservative and safe for them, especially when facing the uncertainty of learning under tough market competition.

The attainment of managerial autonomy and the cooperation with MNCs had not automatically brought about effective learning for product technologies. As for those previous indigenous product platforms of corresponding SOEs[51] before they set up JVs with MNCs, most of these platforms had been abandoned or marginalised with their TMFT practice; and new product platforms had not been established. Only a very few exceptions were found in the five industries

[51] For examples, before they set up JVs with MNCs, FAW had the *RedFlag* platform; Beijing Auto had the *BJ212* platform; and SAIC had the *Shanghai* platform.

we ever investigated[52].

The lack of product development activities uprooted capability building for in-house product development. Such a situation also gradually removed the long-term intent of Group-A firms towards indigenous technological capability building. Finally, Group-A firms were captured by the profit-making based on the extension of production capacity.

5.2.1 Governmental impacts

As mentioned in Section 4.3.4, there were two expectations that the Chinese government had on the TMFT practices of Group-A firms, namely to have foreign partners and learn from them closely, and to follow a bottom-up learning pattern.

Besides, in the early phase of TMFT practices, it was the government that worked as the commander to mobilise high quality state-owned assets to set up Sino-foreign productive JVs. Therefore, there was no possibility for relevant SOEs being ignorant of the original targets of the policy-makers about this policy, namely to realise indigenous capability building as well as import substitution. However, the government also had little knowledge about how to realise this target in practice. Hence, the governmental impacts on the TMFT practices must be studied through policy practices in addition to their slogans and macro guidelines.

In practice, to localise the production became the primary mission that policy-makers stressed for SOEs involved in the TMFT framework. In the early 2000s, even after the target of import substitution had been largely achieved in many industries, production localisation was still underlined as a first-place task. The inclination can be interpreted mainly by two points.

Firstly, policy-makers, with the indoctrination of foreign firms and economists, worshipped economies of scale. In the automobile industry, policy-makers even pointed out articulately that the production capacity of 300,000 set/year was a basic line for the survival of a single automobile maker, which was partly extended from the viewpoint of Maxcy and Silberston (1959). As the advanced indigenous product models were absent, the localisation of production of imported product models was seemingly the necessity for realising the economies of scale.

Secondly, policy-makers broadly had a linear bottom-up model of technological learning in their mindset (Lu and Feng, 2005). By this model, the importation of foreign product models was

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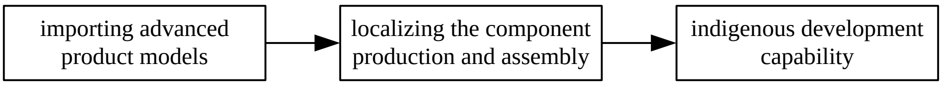
[52] Shanghai-Mitsubishi Elevator (SMEC) is a positive example that became independent again through a contest of corporate control against Mitsubishi. Mitsubishi had already moved away from the governance and technological learning of this JV, i.e. Mitsubishi had stopped providing any new product models for SMEC. But with its own technological learning and in-house product development, SMEC remain a top domestic equipment provider, and is sustainably competitive with reference to international giants in the Chinese market. In the car-making sector, ChangAn and Brilliant have kept investing intensively in technological learning in their subsidiaries stressing in-house product development although they also have Sino-foreign JVs. But both these two established JVs quite late compared with other backbone SOES involved in TMFT, and they had already built up strong in-house product development lines in relevant fields before setting up JVs.

expected to bring about relevant technologies. Then the production localisation, including that of components and end-products, could improve local knowledge about relevant technologies; finally, the knowledge accumulation through production localisation could lead to the growth of indigenous technological capability. In the "Outline of National Industrial Policy in 1990s" of China announced in 1994, this model was summarised as "*import – assimilation – absorption*".

Figure 5.1 Linear bottom-up model of technological learning



Source: F. Lu and Feng, 2005, p24

Therefore, production localisation was regarded as not only the key to commercial survival, but also a primary and necessary step for effective technological learning. As for key projects, the process of production localisation even became the issue of the whole Chinese society. In 1988, RongJi Zhu[53] even required the SAIC to promise that the localisation rate of the production of "*Santana*" (the first imported model of Shanghai-Volkswagen) would reach 25% by 1988 and 50% by 1989. Based on the original JV contract, Chinese government expected it to be 80% in 1991, namely in 7 years after setting up the JV. This situation was general for Group-A firms in different industries. In its early phase, Shanghai-Bell was expected to actualise 20% of production localisation soon after the foundation and 70% by 1993 (X.Shen, 1999, p91).

On the other hand, Group-A firms were also eager to speed up the localisation of production because it was closely connected to their capacity for profit making. Before 1989, Shanghai-Bell stayed in deficit all the time. One important reason was the low rate of component localisation that the cost in sum of imported components they used was even higher than the price of the same product imported in a completely assembled manner. Thus, to increase the production localisation, and to make use of the domestic human resources and other economic factors to lower the cost was a common urgent task for Group-A firms. Table 5.1 and Table 5.2 present examples of the progress of production localisation.

Table 5.1 Production localisation rate of components of *Santana* (Shanghai-Volkswagen)

Year	1984	1986	1987	1988	1989	1990	2000
Production localisation rate, %	NA	2.7	12.6	30.6	60	70	92

Source: collected from documents

[53] ZHU was the Mayor of Shanghai in 1988-1991, the Vice Primer in charge of economy in 1993-1998, and the Primer in 1998 -2003, who was a major executor of the SOE reform and TMFT framework at that country level.

Table 5.2 Localisation rate of components of PDSS (Group-A firms, 1997)

Firm	Shanghai-Bell	Beijing-international	Tianjin-NEC	Guangdong-Nortel	*Qingdao-Lucent*	JiangSu-Fujitsu	Nanjing-Ericsson
Rate	70%	60%	50%	About 50%	About 50%	40%	25%

Source: Zhang (2003)

5.2.2 Financial concerns

For Group-A firms, financial tensions were common in their early phases. There were two reasons: firstly, they did not have extensive financial resources before TMFT. The small scale of domestic industries led to the limited financial capability. As we know, the shortage of finances actually was a substantial reason for the Chinese to invent the TMFT policy; secondly, to produce imported models by setting up JVs with MNCs was still expensive.

Even though the TMFT framework included MNCs as shareholders, technology transfer was still costly. Taking the car-making sector as an instance, it costs hundreds of million of USD for importing each car model from overseas[54], although the specific price of each project varied. Besides, the deal of production permission for car models was usually bound with agreement of the production royalties, the procurement of equipment, and the deal for importing CKD assemblies and components. The bound agreements could pile up more financial costs. For example, when FAW-Volkswagen was set up to import the *Jetta-A2* model, a manufacturing line of Volkswagen's in Westmoreland (Pennsylvania, U.S.) was disassembled and moved to China. For the *Jetta-A2* model and the equipment, the Chinese side had to pay Volkswagen 11.13 billion RMB. It is worth mentioning that Volkswagen in its global mainstream market was abandoning the Jetta-A2 model[55] so that the factory in Westmoreland had been retired early in 1988[56]. Table 5.3 lists the initial expenditures for the model imports and relevant equipment procurement from foreign partners of Group-A firms[57]. We also demonstrate the initial financial capacity that Group-B firms had at establishment to show the contrast and prove how expensive the TMFT could be.

[54] In most cases, what the JV obtained through paying this fee was only the production permission of corresponding models, i.e. Sino-foreign JVs did not have the IPRs of relevant models. Except for special statement all terms relevant to the importation of product models in this thesis refers to this interpretation here.
[55] *Jetta-A2* was officially replaced by *Jetta-A3* in 1992 by Volkswagen for its global mainstream market.
[56] This manufacturing line was established to produce the *Golf* before. In the whole deal of FAW-Volkswagen cooperation, it was priced at 25 million USD. But it was made with additional conditions: the Chinese side had to import 14,500 sets of Audi-100 CKD kits by the price in 1987.
[57] The equipment procured from foreign partners did not fulfil certainly the basic needs for production. In many cases, in order to save money, SOEs would not import the full set of machines.

Table 5.3 Initial expenditures of Group-A and B firms (unit: billion RMB)

Group-A Firms	Initial expenditures for importing models & equipment	Note
Shanghai-Volkswagen	3.58 (=1.54, in USD, c.p.)	In 1984. The expenditure was for importing the *Santana* model and some production equipment (not including supply chain)
FAW-Volkswagen	11.13 (=2.09, in USD, c.p.)	In 1991. The expenditure was for importing the *Jetta-2* model and some production equipment (not including supply chain)
DongFeng-Citroën	13 (=2.36, in USD, c.p.)	In 1992. The expenditure was for importing the *Citroën-ZX* model and some production equipment (not including supply chain)
Group-B Firms	Registered capital[58]	Note
Chery	1.75 (in fact, 0.7-0.8) (=0.21/0.08-0.10 in USD, c.p.)	In 1997. The real fund Chery had was less, only about 0.7-0.8 billion. The expenditure was for the first-stage construction of infrastructures (manufacturing lines, R&D laboratories, etc.) and the development of the first car model.
Geely	0.5 (in fact, 0.1) (=0.06/0.01, in USD, c.p.)	In 1997. The real fund Geely had was less, only about 0.1 billion. The expenditure was for the first-stage construction of infrastructures (manufacturing lines, R&D laboratories, etc.) and the development of the first industrialised car model.
HaFei	0.9 (not registered capital) (=0.11 in USD, c.p.)	In 2002. The expenditure was for the third-stage construction of its infrastructures (manufacturing lines, R&D laboratories, etc.), which were set up for its first car model and other two vehicle models and for the development of the first car model.

Note: The "c.p."refers to Current Price of foreign exchanges.

In addition to the initial expenditure for model imports and equipment procurement, JVs still had to raise funds for CKD component imports, other equipment imports, training personnel in the foreign side, technical consultancy, technical certifications, and once again, all the similar fees for importing the subsystem and component designs and realising the localisation of production.

Therefore, although the fee for technical transfer was only one of the major expenditures that were presented clearly in most main JV contracts, the total practical expenditures for completing the physical construction of production localisation were usually several times more than the fee for technical transfer. Take the CKD imports as an example. Shanghai-Volkswagen planed to produce 89,000 sets of *Santana* by importing almost full set of CKD kits before it realised 60% of the localisation. For the CKD imports of each set, Shanghai-Volkswagen had to pay 10,000 USD to the Volkswagen side. So for the CKD kits alone during this period, it had to pay 0.89 billion USD which was more than half of the initial fee for technical transfer and partial equipment imports. Indeed, when the 60% target was achieved in 1990, the real imports of CKD kits had exceeded 89,000 sets. This did not mean Shanghai-Volkswagen stopped importing assemblies and components from the overseas Volkswagen network, but this just meant that the JV stopped buying almost full set CKD kits to produce this model. For all relevant expenditures (see Table

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[58] Group-B firms announced more capital than they in fact had, because there was still floor requirements of financial capacity that was enacted by the industrial regulator.

5.4), most of them went to the foreign partners and their global value network. Therefore, for the MNCs, these incomes were steady. Even though Sino-foreign JVs could meet the deficit, but only if the JVs did not encounter serious difficulties and ceased normal production, benefits for MNCs could be guaranteed through components trades, technical services, production royalties, etc. These business activities, demonstrating as inputs of Sino-foreign JVs, also brought in significant incomes to MNCs.

Table 5.4 Fees paid to foreign partners for establishing Sino-foreign JVs under the TMFT policy

Item	Note
Technical transfer fee	For the permissions and the blueprints for localised production
Technical Royalty	For each product (subsystem) produced with IPRs (Intellectual Property Rights) of foreign partners
KD imports	For importing the CKD/SKD kits
Equipment & instruments	For importing relevant equipment and instruments
Training	For personnel training to ensure the proper manipulation of equipment
Technical consultancy	For employing foreign experts to help settle technical problems
Technical certifications	For technical certification: every technical/production segment of JVs must achieve the certification of its foreign parent firm, since the latter retains possession of the brand and (or) design.
Commissions	For the production licence (technologies or brands): usually 4.5-6% in the car sector, and 2-6% in the telecom-equipment sector
Transfer fee for subsystems & components	For firms to produce locally the sub-systems or components of the imported designs: all the fees above
Others	For many other items we have not investigated

Therefore, reconsider the controversy among policy-makers about patterns of introducing foreign technologies in the early 1980s. Even though the TMFT policy could introduce MNCs as stakeholders and bring about high-packaged technological transfer, its industrial practices were still costly, which was beyond the expectation of Chinese participants. However, as too huge expenditures had been made step-by-step, relevant people in charge had to keep silent, but just hope for good outcomes. Among these expenditures, the central government and regional governments provided quite a lot. Regarding the 7th - 8th FYP (during 1986-1995), about 18 billion USD from the state revenues were appropriated for the establishment of JVs between the backbone SOEs with MNCs, without mentioning that from regional governments. Hence, there were multiple domestic stakeholders looking forward to get repaid through rapid development of Group-A firms, including (i) the government that expected to be repaid through crowding-in and multiplier effects of the investment, and *via* the tax revenues, (ii) relevant local banks which had been coordinated by government to credit Group-A firms with preferential treatment, (iii) local allied or affiliated supportive firms that had made complementary investments, and (iv) employees who in general were eager for stable improvement of welfare compared with the difficulties of SOEs in the 1980s and 1990s. These stakeholders inevitably had the voice in the decision-making of Group-A firms. Under such pressures, Group-A firms, unless they were extraordinarily risk-oriented, would be inclined to do their best to shorten the period of costrecovery. For this purpose, to promote the localisation of production was critical as an urgent and comparatively reliable strategy. By contrast, any other kinds of capability explorations were certainly placed inferior during this course.

On the other hand, the financial concern had become broadly adopted nominal excuses of Group-A firms to rationalise the absence of their indigenous product platform development. Nevertheless, this could be regarded as only excuse. As can be seen from Table 5.3, compared with Group-A firms, the financial status of Group-B firms in their starting-up phases could be regarded as barren but they still successfully began product development from their early phases. Therefore, the financial deficiencies in early phases were not necessary to keep Group-A firms away from product development and technical exploration. However when Group-A firms believed there were other better ways or aimed to avoid the uncertainty of technological learning, financial shortage became very good excuses for them to validate their choices. Worse was the fact that financial difficulties were temporary situations for most Group-A firms[59], but their strategies and behaviour, which made the development of products and complex technologies to the inferior significance, were gradually embedded in their organisational cultures and traditions.

Therefore, it was not difficult to understand that FAW abandoned the existing RedFlag platform in 1994. The cases of Shanghai-Bell below demonstrates exactly how the decisions for short-term trade-offs gradually led to the change of foundations of organisation.

TextBox 5.1 Two controversies within Shanghai-Bell

In 1988, Shanghai-Bell developed a RASM (remote autonomous switching module) to optimize the application of *S1240* based on the demand characters of the Chinese market. After the launch of RASM, an internal controversy occurred. A group of old engineers, who had product development experience before joining Shanghai-Bell, insisted on carrying out further technical exploration since they took this as a good starting point to deepen the knowledge base for Shanghai-Bell. On the contrary, a group of young engineers, who were college graduates before entering Shanghai-Bell, criticised this proposal as the legacy of the command economy, namely investing in basic research without considering economic efficiency. They argued that Shanghai-Bell should make use of the technical resources of Bell Global, and only respond to visible market demands.

The executives supported the opinion of the young engineers. The old engineers were solaced by a promise that Shanghai-Bell would invest more in technical exploration when its financial status became better in the future[60]. Another similar controversy happened in 1992 after developing a

[59] Shanghai-Bell gained profits in the financial sheet from 1988 on, after 4 years of the TMFT practice, FAW-Volkswagen from 1995, also in 4 years.

[60] The year 1988 was the first that Shanghai-Bell achieved financial profits. Before that, Shanghai-Bell was in deficit.

CuAE (customer application engineering) software package[61]. The executives made the same decision with the same excuse, although the financial status had improved significantly. In fact, the decisions were made only for handling the temporary situations at those moments. Executives did not intend to remove the long-term intent to carry out in-depth technological learning in the organisation. However, the results did change the cultures and visions among first-line engineers, that indigenous technical exploration became an undesirable topic to discuss. Similar spontaneous controversies have not happened ever since.

During 1989-2001, Shanghai-Bell did not stay in deficit. Its production capacity grew fast to 15 times the designing capacity of 1995; it even became the No.1 PDSS maker of the world in 2001 with 17,000,000 lines of PDSS output. Along with the growth of production capacity, the retained profits increased. It had 1.16 billion RMB in 1994. However, there was no spontaneous controversy among front-line engineers about indigenous technical exploration after 1992. Even though during most of the 1990s Shanghai-Bell kept investing 5%-7% of sales in R&D, the firm had not developed effective mechanism and the organisational members had not been effectively mobilised to carry out in-depth technical exploration or product development. Hence, before 2001, only one patent had been developed by Shanghai-Bell, which was the RASM model mentioned in the first internal controversy (see Textbox 5.1). And it was exactly because of the absence of in-house product development capabilities, the dominance of Shanghai-Bell had to be traded over to the foreign side (by holding 50%+1 stock share) in 2001, because the Chinese side had no bargaining power considering the continual dependency on imported product designs.

5.2.3 Negative attitude of foreign partners

Regarding the foreign side, the attractiveness of the TMFT framework originated from the favourable treatments provided by the Chinese government, the potential of the Chinese market and the low productive cost, so that MNCs had consensus with the Chinese side to enlarge the production capacity rapidly. However, MNCs displayed different attitude with the Chinese side on developing technological capabilities of JVs locally beyond just being manufacturing and local marketing bases, since they did not want to raise any potential competitor against themselves. Compared with the inexperienced Chinese government and SOEs under the new circumstances, most MNCs did have roadmaps to protect their benefits in the TMFT framework.

(1) Attitudes

During 1980s-1990s, most MNCs were firmly negative about the product exports of Sino-foreign

[61] CuAE is one software package at the application layer, which is designed to generate specific customer application software upon the corresponding customer demands. The CuAE developed by Shanghai-Bell was so successful that some other subsidiaries of BTM worldwide also bought it from Shanghai-Bell.

JVs under the TMFT framework even though exportation had been formulated in original JV contracts in many cases[62].

The statement of the Belgian General Manager of Shanghai-Bell in 1993 identified this attitude clearly: "*It is common knowledge that, through technology transfer, the technology supplier wants to create markets rather than create competitors... if Shanghai-Bell attempts to export, the process of technology transfer will be slowed down on the Alcatel side. Obviously, Alcatel doesn't want to have a rival who is as strong as itself in technology"* (X. Shen, 1999, p82). In such circumstances, the exports of Shanghai-Bell never reached 30% before 1999. However, according to the original JV contract, to export products of Shanghai-Bell based on imported designs was designed explicitly as a critical way to balance the forex reserves of the Chinese side. Given the shortage of forex at that time, China asked for a governmental loan from Belgium to set up Shanghai-Bell. For this sake, 30% of the annual output of this JV had been expected in the contract to the exports. However, it was obviously not in the interests of the Belgian BTM in the global market and they did not support this in practice. When conflicts occurred within the directorate board of Shanghai-Bell, the Chinese executives had no effective way to have the foreign side on the contract since the JV still had to rely on the technological inputs from the foreign side to complete the production localisation of relevant components.

In fact, the difference of opinion in product exports between the Chinese and the foreign sides was general in most cases under TMFT framework. In the phase of negotiation of JV plans, this difference of opinion played significant role in the failures of many cases. Even for those MNCs that finally agreed to cooperate, they also refused the suggestions of the Chinese about product exports, such as the AMC (with Beijing Auto) and the Volkswagen (with SAIC). When Volkswagen considered establishing a second productive JV in China in 1987, FAW suggested an export-oriented plan, but this proposal was firmly declined by the Germans (Hahn, 2005, p133).

In the car-making sector, only Guangzhou-Honda, in which Honda owned 70% stake and the Chinese side just worked simply as a shareholder, had regularly exported a significant amount of products[63]. Similarly, the ratio of exports in Shanghai-Bell grew significantly after it was dominated by Alcatel in 2001[64]. However, after Shanghai-Bell had become the global

[62] In order not to generate misunderstanding, we must point out that our discussion here related only to the productive Sino-foreign JVs that were set up under the TMFT framework, and was not applicable to the foreign wholly-owned or dominated firms in China. Those foreign wholly-owned or dominated firms that emerged in large number especially after 1991 (for the incentive of the Chinese government by the 1991 Income Tax Law for FFEs), especially in consumer electronics, garment, etc., were built to make use of Chinese comparative advantage of production cost and actually turned China into the "global factory".

[63] Guangzhou-Honda is a special JV in China. The Chinese insisted that the domestic side owned at least 50% stake in the Sino-foreign JVs in the car-making sector. However, Honda persuaded the Chinese government with its export-oriented scheme. In the telecom-equipment and other industries, there was no such regulation.

[64] In fact, the export of Shanghai-Bell had started to grow significantly from 1999. One reason was the insistence of the Chinese side, because in 1998 the MPT system was reformed into the MII, and the new authority went back to stressing

manufacturing centre for the Alcatel-Lucent group, the brands of products it provided became the "Alcatel" and "Alcatel-Lucent" only in international markets.

Compared with their attitudes in product exports, the foreign sides had much more negative about the local in-depth exploration of product technologies carried out by JVs, even though the learning could be already formulated in original JV contracts.

For example, in Shanghai-Volkswagen, soon after the establishment of this JV, the Chinese side found that there was no practical effective arrangement to generate product-related technologies (Liu, 1992, p264). Instead, the German side proposed to build this JV into a pure manufacturing base for a single model, namely a *Santana* model. According to Welkener, who was the assistant managing director and the chief of the German team in Shanghai-Volkswagen at that time, if the Chinese side accepted his proposal, through continuous improvement without major changes of design, the *Santana* could be produced at 5,000 USD per set around 2000, and then "*...Santana would be the most competitive car in the world*" (ibid).

The Chinese side insisted that the JV should aim at developing the capabilities of engineering design as being agreed in the original contract. The German side did not accept that and defended itself with a series of "practical difficulties", especially those about the weakness of the Chinese in resource-based factors. After the intervention of the Chinese government, the German side had to put forward three alternative options to Shanghai-Volkswagen in the early 1990s, as possible ways to cultivate the capability to generate a next-generation product. The first was to take over a brand new model designed by Volkswagen; the second was to take over a already mature model from Volkswagen; and the third was to design a brand new model together that would be suitable for Chinese market and have export potential.

The Chinese side took the third. However, during the cooperation, the German side had not respond actively and efficiently to all requests from the Chinese side about sending experienced experts, using equipment, teaching methods and providing consultant services. Thereby, it was very difficult to implement the joint design so that the project was adjusted again and again. Finally, the Chinese had to agree on a "*new"* project, namely the *Santana*-2000 that was started in 1993 and launched in 1995. The *Santana*-2000 project was dominated by German engineers, carried by the Volkswagen's subsidiary in Brazil, and was still based on the *Passat-B2* platform as the original version of the *Santana* was. No important change relevant to the product platform had been made. However, by this project, Volkswagen announced that it had already fulfilled its duty of cooperative development for this stage. In fact, all the Chinese could do was just to send 10

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this point in the original contract. The second reason was more important: after 1998, the growth rate of the Chinese PDSS market had slowed down. But Shanghai-Bell had not diversified with product lines before 2001, and the rise of Group-B firms seriously limited its market share for the PDSS products. Therefore, the foreign stakeholders changed their strategy.

engineers to Brazil under the permission of Volkswagen.

In other JVs, situations were similar. In Beijing-AMC (later Beijing-Chrysler), an R&D centre was schemed in the JV contract. However, because of the reluctance of the American side, not until 1995, 10 years later than expected, this centre was not built up. Moreover, when the Chinese side sent engineers to AMC and Chrysler as contracted to be trained for the R&D centre, the American side insisted that Chinese engineers could not enter any area involving the activities of product development within their places. Even after the centre had been constructed, it was unwelcomed by the American side. In 2002 when Beijing-Chrysler was moved to another factory site, this R&D centre was temporarily dismissed. However, it was not built up again as expected because of the non-cooperation of the foreign side.

(2) Methods of control

More important were the methods of the foreign sides to restrain the technological learning of Group-A firms. In general, foreign sides controlled the technical information provided for their Chinese collaborators, and controlled the technical improvement procedures of JVs. These measures could prevent learning practices entailing product development and product technology from happening.

(i) Control of technical information

The technical information that foreign partners provided for the Chinese sides was often incomplete and fragmentary. Generally, the foreign partners were not willing to provide any information beyond the necessary for achieving the production localisation as schemed. Therefore, two kinds of data could be found as missing from packages that Group-A firms obtained from foreign partners.

Firstly, the data specifically relevant to product design and engineering development other than for manufacturing were possibly absent. Information in blueprints from foreign sides embodied mainly the structural layouts of objects, the processing requirements and the introduction of materials adopted, i.e. the information about how to manufacture the corresponding objectives instead of development process. That is to say, the knowledge about "why design details are made like this", and "by what methods these design details are realised" was not included.

For example, an LSI (Large Scale Integration) chip provider named BeiLing was founded as a complementary cooperation to provide chips for Shanghai-Bell. This plant was equipped with processing capabilities that were embodied in its equipment. BeiLing could realise processing precision at 3-micrometer level and could produce 13 different LSI chips. However, the Belgian side provided no information about the designs of corresponding chips. What BeiLing obtained was equipment and processing procedures and data. Then all it could do was to produce chips that had already been well encapsulated beforehand. Therefore, what Chinese partners could learn and could do was just to manufacture, which in essence, in Richardson's terms (1972, p889), had complementarity, but absolutely had not similarity to the developmental activities that the Chinese should need for building the indigenous technological capabilities for product development.

The situations in the car-making sector were similar. Among all the activities cooperatively implemented in the JVs, only those relevant to the adjustment of designs entailed product design and engineering development tasks. For these projects, the foreign sides would provide relevant original design details as references. For example, in order to meet the preferences of local customers, the models of *Elysée* and *FuKang*[65] had been adjusted by DongFeng-Citroën. During these projects, Citroën provided corresponding data of the original front-face designs to be altered. Furthermore, since the JV planned to make use of the local supply chain of engine production, Citroën also provided precisely relevant data for matching the engine systems – which were not general data about the engines. It also did not mean the JV had the properties of relevant original data transferred inward during the cooperation.

Secondly, even for the information related to manufacturing requirements, what MNCs provided in many cases was only the minimum subset of necessary information for manufacturing activities really carried out locally by Sino-foreign JVs. For example, in the FAW-Toyota (JV) and FAW-Mazda (cooperative production), Chinese engineers found that the blueprints handed over by their Japanese partners had been scissored. This meant that before delivering these blueprints, the foreign partners had already eliminated the "inessential" information from printed drawings and relevant digital documents. The scissored information was deliberately selected to eliminate any information beyond the needs for appointing localised manufacturing. For instance, details entailing the KD components or services that were imported from the MNCs' value networks were eliminated. Only the necessary interface data for assembly remained. When Chinese engineers asked foreign representatives for the corresponding details, answers were always that those were business secrets of their parent company, namely the foreign side. For example, as the dies for the A-surface plates of engine hood of the *Mazda-6* model produced in FAW were provided by the foreign side, the information of pressing requirements for A-surface plates was scissored from the blueprints delivered to Chinese engineers. Similarly, when FAW imported the *Dodge-600* engine model from Chrysler in 1987, Chrysler provided only the blueprint for the general layout of this engine. In order to know the details of KD components since these details were necessary for promoting the production localisation rate, FAW had to pay additional fees, after the deal of engine model transfer had been done, at 10,000 USD per page for over 500 sheets of blueprint to Chrysler. In addition, this could happen only because Chrysler respected the

[65] *FuKang* is the localised model of *Citroën-ZX*, and *Elysée* is the localised model of *Citroën-ZX-988*.

potential to reach a JV agreement with FAW. Even more astonishingly in Shanghai-Volkswagen, Chinese engineers do not have a full list of components and parts for any car model they have ever produced even today, although some models are outdated in the market. In other words, after 30 years of close learning from foreign partners, Chinese engineers there even cannot work out a full name list of disassemble components and parts of products they work on from day to day, not to mention the component details.

The scissored information could be very important for Chinese engineers to develop systemic understandings of the products. Within the complicated systems, technical details were highly interconnected. So lacking the technical information of particular details might form critical obstacles against learners to understand the others or the entire system. Moreover, the fact was that they did not just lack a bit but much of detailed information. Therefore, this strategy of foreign sides did hinder Chinese engineers from implementing reverse-engineering easily, not to mention reproducing the original developmental process. This made the “close learning” expected by the policy-makers and Group-A firms *de facto* happen quite far away from generating systemic knowledge about product design and relevant engineering development.

(ii) Control of technological improvement procedures

The foreign sides were also able to contain incremental technical advances within JVs by a series of formulated supervising devices. The “*inspecting and confirming right*” was the core for these devices. This method was originally developed to enhance the accountability and quality control in developmental processes. It was meaningful in both technology and governance. In technology, inspecting section was set by the end of every step of development, and inspecting and confirming section was set by the end of every stage. These sections meant to test, examine and approve the corresponding steps or stages of projects. In governance, these procedures indicated that the corresponding developmental tasks had been approbated. However, the approbations were made legally only by the chief experts exactly having the rights vested by the project scheme.

So, as owners of imported designs and corresponding brands, MNCs had the right to control technical improvements based on them. For most cases in Group-A firms, JVs only had the permission to produce imported models by paying fees for the importation of these models, which did not mean they had the corresponding IPRs. Moreover, most incremental improvement projects carried out by Group-A firms were not to develop new models, but to adjust designs based on original models. Although JVs could retain the designs of adjustment they developed, their adjustment still had to rely on the rest complementary original designs for practical uses. Besides, in most cases, adjusted models were still labelled with original brands, which again was a question of trademarks entailing the foreign side. Therefore, the foreign sides had proper excuses to control this behaviour in the name of protecting the benefits from their property, which endowed them with the dominant role over "*inspecting and confirming rights*".

The tactics usually adopted by MNCs to depress technical changes they did not favour were the manipulation of time and quality requirements. Since the inspection and confirmation of critical sections were implemented by the foreign sides in their headquarters, the Chinese sides had no control over how long the certification should take and what qualitative standards the adjustments ought to reach. These controls were in the hand of the MNCs. Nearly never-ending time requirements and unrealistic standards could be set by foreign sides to eliminate unfavourable technical schemes or to induce these schemes to change favourably for them. Finally, Chinese engineers all recognised that they did not have practical rights to lead any project relevant to product development and complex technologies[66]. It was a common complaint of Chinese engineers that in Group-A firms even for revision of just one bolt, they had no real decision-making power but were obliged to refer to permission of the MNCs.

The hinge problem of the *Santana*'s rear doors was typical for explaining this point. When problems occurred, Chinese engineers had no rights or resources available to fix them, while Germans were not motivated to handle them as soon as possible. Not until it turned into a severe political and strategic issue even entailing a vice premier of China, was the problem solved[67].

Hence, regarding the practical effects, this method had the incremental technical improvement of products under the supervision of MNCs rather than being decided by the insiders of JVs or by the parent Chinese SOEs. Decisions were made to serve the global benefits of MNCs rather than the expectations of Sino-foreign JVs or the initial expectations of Chinese policy-makers. It was to say, the nominal expectations of building in-house technological capability were also manipulated by foreign sides mainly that were outsiders to this target. In the autobiography of Carl Hahn (the president of Volkswagen during 1982-1993), he articulates that the German side indeed was in charge of product technologies in these productive Sino-foreign JVs, including FAW-Volkswagen,

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[66] We only met two exception cases during the fieldwork. One was the FAW's styling adjustment to the *Jetta* model in 1998. Since it was not part of Volkswagen's plans, FAW had to pay special fees from its own account to the German side for relevant original data and authorisation to adjust the front face and some other exteriors. These developmental activities were finally allowed to be carried out mainly in China. The amount of the fee is kept as a business secret, but conservatively estimated to be 70-80 million USD. The adjustment had to be under the supervision of the German side, and the outcomes belong to the JV not the Chinese side unilaterally. As another case, the former chief engineer of Nanjing-Fiat from the Chinese side also announced that he had shared the inspecting and confirming rights in some design localising projects. But this happened only given an abnormal context within the Nanjing-Fiat. At that time, Chinese executives had been seriously competing against foreign executives over the control of resource since the foreign side was found to be planning by stealth to establish another productive Sino-foreign JV with other SOEs and with competitive product schemes against that of Nanjing-Fiat. For this reason, the Chinese directors supported the chief engineer in claiming shared decision-making power over these projects without respect to any result. Indeed, he did not get good cooperation from the foreign side. This JV was ended in 2007.

[67] Abnormal noises from the hinges of *Santana*'s rear doors were reported by Chinese engineers in 1986. However, the German side did not react swiftly to improve this for the Chinese market, and Chinese engineers did not have the rights to carry out relevant changes. Not until a vice-premier of China spoke to the president of Volkswagen in 1987 did German realise that their Chinese partners had been really annoyed by this problem, which was related to the general reputation of Volkswagen in China. Only after that, was this technical problem solved by Volkswagen (Hahn, 2005).

Shanghai-Volkswagen and other JV suppliers (Hahn, 2005, p119).

Even for the learning within Group-A firms associated with processing technologies, the foreign sides were not always ready to cooperate. This was because, as mentioned previously, the benefits of MNCs in running Sino-foreign JVs came not only from producing and selling end-products but also from businesses relevant to component, equipment and technical services trades. Then the rapid capability growth of JVs in processing technology was not always in the interests of MNCs. Another case of *Santana*'s car door demonstrated this point clearly. In its early phase, Shanghai-Volkswagen was criticized for the imprecise clearance between the car body and the doors. Since the German side was reluctant to offer any know-how to fix this problem, Chinese had to implement a series of remedial measures to improve the quality: they firstly turned to importing steel plates directly from the original supplier of Volkswagen in Europe instead of making use of local suppliers, but this did not fix the problem. Then the Chinese side chose to purchase another complete set of stamping lines, even though most equipment of the previous line was also imported but not 100% from the Volkswagen network. But the improvement brought by the new line was almost invisible. Finally, SAIC had to buy a Germany company which ever provided the same door assembly for Volkswagen, and then got the secret: it was just to hold the punch mould in its final position for several seconds before it was pulled back! The Volkswagen side knew this little thing clearly but just witnessed their Chinese spending money.

<u>(iii) Other methods</u>

In some cases, the decisions of JVs about equipment adoption also needed the approval from MNCs, entailing the types of equipment, the providers and the technical parameters (Shen, 1999, p78-79). In other cases, managers from MNCs controlled the IPR department of JVs, such as in DongFeng-Nissan and Shanghai-Bell. These measures certainly enhanced the abilities of foreign sides to control the development process in JVs.

In short, the Sino-foreign JVs could not obtain complete information by studying blueprints and activities introduced by their foreign partners. They also could not freely generate product improvements on their own. By these means, MNCs worked as supervisors to detaining Chinese learners from being potential competitors. As for the Chinese side, the JVs did not really work as the loci to develop products, or the loci to cultivate the capabilities for product development.

5.2.4 Production localisation activities: to imitate as similarly as possible

According to their linear model of bottom-up technological learning, Group-A firms believed that the practices of manufacturing advanced products could smoothly bring about the technological capabilities as by-products in the nominally homologous domains related to the products but in the heterogeneous more advanced categories of capabilities[68]. The critical consideration in their mindset was to speed up the manufacturing localisation efficiently. To imitate the imported models as similarly as possible consequently became a convenient way to reduce the time and resource consumption.

In the Chinese aircraft-making industry, the "*Derivative Method (YuanZhun Fa)*" had been used for decades for the Chinese learning of Soviet benchmarks. The essential feature of this pattern was that, when encountering any technical problem during incremental product improvement, the decision-making should refer to the Soviet experts (prior to the Sino-Soviet Split) or the imported original Soviet designs. Decision-makers believed that, considering the complexity of the aircraft product system, such a strategy was efficient to ensure reliability. Certainly, to decision-makers, it was just a pattern to solve problematic details of design. However, it indeed led to the aversion to any remarkable technical risks in the mainstream thinking of product development, which prevented front-line learners from generating systemic understanding of products, and hindered underlying technical explorations that entailed uncertainty.

We do not intend to explore the cognitive linkages about learning within the Chinese domestic industries. However, the stress on imitation by Group-A firms in the two sectors we study was even more severe. Decision-makers required the front-line practitioners to stick to imported models during the production localisation, and opposed almost any heterogeneous development coming out with impenetrable uncertainties against their very limited neighbourhood of knowledge at that time. Even those attempts that had been made to imitate the given models but finally turned out with different results would also be replaced by "better" plans to yield exactly the same outcomes as the benchmarks. Otherwise, developers were asked to check where the "mistake" resided. In short, the learning platform was constructed based on activities to realise production localisation; heterogeneous ideas of individuals were not supported. So these ideas were unlikely to be incorporated by the organisational SECI processes, and were unlikely to be incorporated into collective memories.

Therefore, during the practice of production localisation, in addition to earning experience from day to day, the learning carried out by front-line Chinese included training to study the dimensions of existing models, to study the operations of equipment, to study the managerial approaches, etc.

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[68] Then during the process of foreign partners hunting, Chinese sides had inclination to seek cooperation based on emerging products in spite of the fact that what they obtained through this cooperation were just permissions for production localisation in most cases. For example, in the case of Shanghai-Bell, Belgium BTM was appreciated by MPT because the *S1240* system was one distributed-control system that had just emerged in the global telecom industry at that time. Moreover, the Belgian side consented to transferring the production of the LSI chip to China, which was critical for Chinese to make their final decision. Regarding the negotiation between FAW and Audi that led to an agreement in 1988, the German side's attitude to have the possibility of licensing the Audi-100 was the key to FAW's enthusiasm, as *Audi-100* (launched in 1983) was regarded by Chinese as a new advanced (luxury) car model by comparison with many other candidates.

As argued by Kogut and Zander (1992, p391), being taught the functional skills of how to do something is different from being taught how to create it. These learning activities yielded positive outcomes to promote production capacity and processing technologies. However, they had no effective linkage to the expectations of learning about how to erect an effective product development system.

(1) Processing technologies

Processing technologies were the major contents that the Chinese front-line practitioners had learned through TMFT practices. In early phases, Chinese engineers, technicians and workers were categorised into specific groups for training to adapt the new production systems. The contents of training included knowledge about equipment operations, relevant regulations, supplementary skills and principles for efficiency improvement. Foreign experts directly participated in training and production supervision in order to achieve the same quality and efficiency level according to their global standards.

During this, close and day-by-day learning did pay off in most cases. Through learning by doing, Group-A firms had even made a number of innovations in manufacturing processes. For instance, Shanghai-Bell was the first domestic telecom-equipment firm in realising the Computer-Integrated-Making-System that helped to increase the production automation. Also for the *Delta-12*, namely a test device, its processing capacity was promoted by Chinese engineers from 8 minutes per piece to 4 minutes per piece. These innovations contributed remarkably to the rapid growth of production capacity in Shanghai-Bell, which exceeded the original designing production capacity (300,000 line/year) in 1989 (340,000 lines). BTM even adopted the *Delta-12* improved by Chinese engineers in its other global manufacturing bases.

(2) Approach of operational management

As for the approaches of operational management, including those for the management of workshops, firms and industrial chains, Group-A firms did learn much from their foreign partners.

The improvement of operational management was regarded as important for Chinese economic reform at firm level. Before the economic reform, labour relations within SOEs, particularly the *"TieFanWan"* (*"Iron Bowl"*, lifetime employment) and *"DaGuoFan"* (*"Eating from the same big pot"*, absolute egalitarianism) had been broadly criticised as sources of the low efficient managerial control. With the encouragements from the government, reforms within Sino-foreign JVs were realised by incorporating new managerial approaches that were led or introduced by foreign partners while breaking down the previous ones. To cooperate with MNCs was an important source for the Chinese industrial community to adopt the Fordist or TQM (Total Quality Management) patterns, at least for the nominal terms of managerial approaches they learned.

However, we ought to note that going through the TMFT practices was not the only way for the Chinese industrial community to incorporate new managerial approaches, which applied even to Group-A firms. For example, FAW learned JIT (Just In Time) with the assistance of Hino Motors (Japan) from 1989 on, during the process that FAW localised the *LO6S* (a truck model) of Hino by licensing production. Shanghai-Bell had the Bureau VERITAS Quality International to provide consultant services for its quality control system in 1995.

Through the TMFT practices in the past three decades, the manufacturing capabilities of involved domestic firms had overall been evidently improved. In the car-making sector when the first productive Sino-foreign JV was set up, only the rear-view mirrors and the tyres among all local supplies were able to satisfy the quality standards of Volkswagen. In the telecom-equipment sector, the top-performing equipment that could be massively produced locally in the early 1980s were the crossbar switches only, which had long time faded away from mainstream international markets. By comparison, China today has already become the largest producer and exporter of these industries globally. During this process, the normal learning curves worked as to the progress of production localisation of Group-A firms in different phases. For example, the localised rate of *Santana* achieved by the Shanghai-Volkswagen in 6 years was 70% (in 1990). However, for Shanghai-GM that was set up in 1996, 40% of the production localisation for the *Buick* model was achieved in only 2 years. Therefore, we do not mean to underestimate the contribution of the TMFT practices in this way.

(3) In-house product platforms: being neglected

Compared with the stress on production localisation, the development of in-house systemic product was neglected by Group-A firms from their early phases onwards. In their later stages, their organisational learning systems had been built aiming at a business model based on manufacturing localisation, which were difficult for them to transfer and mobilise their organisations for effectively learning of developing complicated systemic products and systems.

Particularly, the in-house systemic product platforms that had ever been owned and developed by relevant SOEs were abandoned, marginalised or transplanted to imported product platforms. As for development under the TMFT framework, there were a few new products developed by Group-A firms. But these projects were implemented in the following manners: first, some of them were set up by engineers spontaneously without permission from corporate authority; second, some originated from divergent opinions within the top authority of firms; third, some were launched under pressure from government and social appeals heading for indigenous innovations; or the fourth, products were developed by the overseas companies that were newly purchased by Group-A firms. None of these projects had been placed at the centre stage of learning activities and resource allocation in Group-A firms; none of them had been well connected to the experience and learning activities that Group-A firms earned and implemented on production localisation.

For details, see the Appendix-1 (Table A – 1.1 and Table A – 1.2).

[Insert Appendix-1 here]

(4) Product adjustment projects

The product adjustment projects were implemented by Sino-foreign JVs to maximize the benefits based on imported product models. We categorise these projects into groups as follows. These projects entailed activities of technical development, whereas all of them were included in the first three categories of development activities in the automobile industry only (refer to Introduction Section of this chapter). Their effects were limited for capability-building because of the ranges they covered and the patterns they were based on.

(i) To adjust imported models to meet the local demand preferences

Regarding the local demand preferences, Group-A firms would make peripheral or moderate adjustments on the imported models. For example, Chinese customers were fond of saloons more than hatchbacks, and did not favour two or three-door cars[69]. In the telecom-equipment sector, telecom-operators would request customised adjustments to meet local regulations or complicated application circumstances. Since relevant local information was necessary, these adjustments were better accomplished closer to the source of information. It explained partly why the RASM, CuAE and Country-Development-Engineering[70] modules of *S1240* system were developed by Chinese engineers of Shanghai-Bell.

Regarding this kind of adjustments, core features of designs were kept untouched, such as the chassis system, the general structure and the frame of the bodywork within a car model. In the telecom-equipment sector, only additional modules were added or were cut down.

(ii) To adjust imported models to suit local supply chains

Time was a critical factor for the progress of manufacturing localisation. So contingently, to make use of existing local supplies was a reasonable alternative when the manufacturing localisation of some components could not be completed in the short time. Therefore, there were adjustment projects to be implemented by Group-A firms or relevant local suppliers. For example, in the car-making sector, ShenYang-Mitsubishi was ever the only domestic independent engine maker before 2001 to provide car engines. Group-A firms and their foreign partners would cooperate

[69] For example, the original models of Peugeot 307 launched in Europe in 2001 were hatchbacks. But for Chinese demand features, the Peugeot 307 was localised into saloon models by DongFeng-PSA in 2004.
[70] The Country-Development-Engineering module is a software package to enable telecom-operators deal with specific situations of network and regulation requirements in practical application circumstances.

with this independent provider if they wanted to adopt its engine.

However, for these projects, as the purpose was time- and investment-saving, the range of adjustments would be strictly controlled, without any in-depth technological exploration involved. Usually, only limited modularised assemblies were included in the scheme, and accordingly only the knowledge of their interfaces was investigated.

(iii) To adjust imported models to extend product life

In order to benefit from sunk costs, adjustments would be made to extend the life of models. As for these projects, the major technical features of models were kept untouched. Only the styling, accessories and some modular assemblies were changed.

In the Chinese car market, the "*Old Three*" were typical cases for extending model lives. The "*Old Three*" were three car models that had led the Chinese car market during most of the 1990s. Among them, *Santana* was launched by Volkswagen in 1981 with the name "*Passat-B2*", *Jetta* by Volkswagen in 1979 with the name "*Jetta-A2*", *FuKang* by Citroën in 1991 with the name "*Citroën-ZX*". In the headquarters of corresponding MNCs, the production of *Passat-B2, Jetta-A2* and *Citroën-ZX* had been stopped respectively in 1988, 1992 and 1998. However, in China, their life cycles had been extended through adjustment projects to generate new versions continuously, which made these models still popular in the Chinese market even today.

In order to achieve technical adjustments, investigations into the evolution of market demands and rival products were implemented locally. The styling and accessories would be re-designed, and the new adopted modular assemblies would be matched. However, as mentioned, most adjustments do not entail in-depth technical change of product systems, and in most cases, these adjustments were led or supervised by the foreign sides.

5.2.5 Sequence of developmental activities

Compared with the growth of their production capacity and manufacturing capability, Group-A firms exhibited inabilities to switch into the new stage of effective technological capability-building for new product development. Very few product development projects had been carried out, and none of them had been placed at the centre of the strategy-making, organisational learning and resource allocation of the firms. As Nelson (1991, p68) points out "*at any time the practiced routines that are built into an organization define a set of things the organization is capable of doing confidently*". Aiming at commercial success, Group-A firms were inclined to duplicate their successful experience of localising the production of imported models, which they had gained and proved to be effective, by gaining profits from the market. The inclination of Group-A firms is embodied in the strategy of Group-A firms continually to set up JVs with different MNCs (see Appendix-4), and continually to import new models. Therefore, returning to routines, the activities that the organisation could carry out with confidence and had been done repeatedly certainly contribute significantly to the evolution of its routine.

In addition to Table 3.2 in Chapter 3, we list the major products produced by the first JVs of SOEs respectively up to 2008. All of these models, except for *BJ2020*, were imported from their foreign partners. The *BJ2020* was taken as an important asset to finance the Beijing-AMC JV[71], but received very little further development.

Table 5.5 Product sequencing of productive Sino-foreign JVs

Firm	Major product platforms manufactured
FAW-VW	Jetta, Audi 100, Audi A6, Audi A4, Golf, Bora, Caddy, etc.
DongFeng-Citroën	Citroën ZX, Citroën Elysée, Citroën Quatre, Citroën Xsara Picasso, Citroën Triomphe, Citroën Visiospace, Citroën C2, Citroën C5, etc.
Shanghai-VW	Santana, Passat, Polo, Gol, Touran, Octavia, etc.
Beijing-Chrysler	BJ2020, Cherokee BJ6420, Cherokee BJ2021, Cherokee Jeep 2500, Cherokee Jeep Star, Chrysler 300C, etc.
Shanghai-Bell	PBX (*SSU12*), PDSS (*S1240*), IDSN and GSM models from the foreign side, etc.

However, the inefficiency of product development could not be simply explained as the lack of R&D investment, as implied by the practical measurement of “absorptive capacity” in the conventional literature. Group-A firms actually invested quite large amount of resources and personnel in in-house R&D, which were obviously superior in terms of absolute amounts compared with their Group-B counterparts when Group-B firms were still in their early phase. This point will be elaborated in Section 6.2.2.3.

In fact, the R&D personnel of Group-A firms also worked actively, but just for projects of “basic research” or “long-run purpose development”. Similar to those marginalised product development projects, the laboratorial jobs engaged fewer cooperative departments, fewer personnel and resources; so these jobs were more feasible for them to implement, since these R&D personnel were marginalised and kept away from the centre of learning in Group-A firms and had not many other choices unless they were also employed in the localisation of production. In fact, the R&D departments of Group-A firms were with intent to act the leading role in the domestic industrial communities for government-funded S&T projects, since by these projects their achievements were easy to measure by the governmental awards with which they were honoured, treasured as tradition in Chinese society. This situation changed only after the technological capabilities of Group-B firms were acknowledged by the government, and then Group-B firms got involved in these projects, which happened in the telecom-equipment sector after 1991, and in the car-making

[71] *BJ2020* (earlier named *BJ212*) was a jeep platform indigenously developed in 1966. Before the 1990s, it was the most popular small size (5 seats -7 seats) passenger vehicle in the Chinese market. Till 2005 when this series were finally stopped production there had been over 1,200,000 sets held by consumers in the Chinese market. In most years before 1990, the profit-making of *BJ2020* was even better than that of the total Beijing-Chrysler (Beijing-AMC in early years). And in the 1990s, *BJ2020* remained a major source of profit for this JV.

sector after the mid 2000s. The more popular and worse situation happening to the R&D division of Group-A firms was that the R&D expenditures were "effectively" consumed by fragmentary projects without systematically scheming for capability- building, by training programmes, by overseas visits, by the participation or organisation of conferences, because the R&D personnel were depressed by their role in their organisations. The product design localisation, the interface the Chinese-characterisation (especially of software), the testing of imported products or equipment were also top candidates to be registered as R&D expenditures.

5.2.6 Analysis and summary

Strategic intent was difficult to measure for the lack of quantitative instruments, especially when the strategic intent of Group-A firms had undergone through an evolutionary process. Therefore, we rely on the study of their developmental activities to identify the corresponding evolution. Strategic intent is not definitely presented exactly by activities in the short term. However, in the long run, the intent requires supports from relevant activities. Otherwise, strategic intent could not last firmly as collective commitment.

Among their activities, it was evident that the localisation of production was taken as primary by Group-A firms. The worship of scale economies and the belief in linear model of bottom-up learning constructed the cognitive conditions for such a strategy. The financial tensions and the negative attitudes of foreign partners over indigenous technological capability building, as well as their business successes based on production localisation, jointly induced and then enhanced such an inclination.

As for learning practices, Group-A firms required their front-line practitioners to imitate the imported models as accurately as possible. Ideas of heterogeneity among those original designs were unwelcome in their SECI process of knowledge conversion. As localisation of production was taken as the major platform to organise activities and to allocate resources, the development of existing product platforms and new products had been abandoned or marginalised. The resources for R&D were expended, but by modes far from being well-schemed and integrated. This in fact enhanced the orientation within the organisations to advocate exclusively a business model based on the expansion of production capacity. Meanwhile, the incentive policy packages provided by governments that were also inexperienced regarding the issue of technological capability building also *de facto* fostered this inclination; so did the first-mover advantages of market power obtained by Group-A firms during the reform.

Hereby, we can say, by observing their activities over the past two decades, the original strategic intent of Group-A firms, namely a joint "technological capability" and "production capacity" orientation as guided by the design of the TMFT policy, had taken place by an exclusive "production capacity" orientation. After 2000, the response made by the decision-makers of

Group-A firms to the public inquiries for indigenous products also revealed this point. They stressed exaggerated resource-based requirements as preconditions for the transition heading the in-house product development: "*... (the preparation to develop systemic products indigenously needs) two generations of engineers, and over two decades…production capacity of 300,000 set/year for individual plants…20 billion USD for R&D'*[72]. They suggested, "*the emergence of indigenous innovation requires preconditions as the production capacity of 5,000,000 set/year of the entire domestic car industry'*[73], and asserted that "*the dominance of indigenous technical standards of electric automobiles shall be consigned to the Nissan which can lead us to a high level capability'*[74], etc.

Certainly, the shift of strategic intent happened by a gradual, evolutionary and uneven process within organisations. In addition, collective change was not applicable to every organisational member at the micro level. Otherwise, we cannot explain why there were consistent brain flows from Group-A firms to Group-B firms, especially when Group-B firms could not provide as good material conditions and benefits for employees as Group-A firms did.

5.3 Strategic intent and developmental activities of Group-B firms

As for the Group-B firms, they seldom received supports from central government. Accordingly, since they were out of the major governmental scheme for the development of relevant industries, there were away from governmental interventions specific to their learning patterns. Meanwhile, as they were not attractive to MNCs in their early phase as JV partners under the TMFT framework, their learning practices were not intertwined with the attempts and actions of foreign collaborators.

5.3.1 Evolution of strategic intent

It was not true that all newborn-local firms insisted on capability-building for systemic product development, which was not easy for DC firm firms especially considering the lack of indigenous capabilities and the market challenge from globalised competition. Group-B firms were exactly the first-movers among domestic firms that insisted on doing this after the TMFT policy had been widely advocated. Their strategic intent could be identified based on their long-term activities.

(1) Chery and Geely

Chery and Geely had both entered the car-making sector when this industry was still strictly

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[72] Referring to the *Dialogue* program of CCTV (China Central Television), 2004-02-15. This was claimed by YanFeng Zhu, the president of FAW and the Alternate Member of the Political Bureau of CCP at that time.
[73] Referring to *China CBN*, 2008-01-21. This was claimed by Yanfeng Zhu. He was the vice-governor of Jilin province (where FAW is located in) and the Alternate Member of the Political Bureau of CCP at that moment.
[74] Referring to the *21st Century Economic Report (web version)*, 2009-04-15, this was said by Wei Miao, the former president of DongFeng, and the vice minister of Ministry of Industry and Information Technology at that time.

regulated with entry barriers. Without official licences, their industry-specific investments bore the risks of losing if the regulator noticed and banned them. Besides, without official licences, they could sell their products only in very limited geographic areas, and it was feasible only if the corresponding regional governments supported them[75]. Undoubtedly, the founders of these two firms were very clearly aware of the risks[76]. However, in spite of these, they continually invested in the development of systemic products from their inception phase onwards.

It was also worth mentioning their opportunity costs. Before entering the car-making sector, Geely had obtained the second largest share in the domestic light motorcycle market segment in China. In order to provide financial support and human resources for its car-making division, Geely gradually retreated from this successful division. As for Chery, its founders were all from other firms where most of them had obtained stable and respectable careers. The current president of Chery was from the FAW and had been honoured as one of the "top-10 young FAWers" in the early 1990s, which indicated he could have a bright future in FAW. Chery's other core engineers who came from the FAW had also been treated as parts of the skeleton engineering force of FAW.

(2) HaFei

After proving their potential in manufacturing and developing systemic car products, HaFei and Chery were invited by MNCs to establish JVs under the TMFT framework. Mitsubishi had made such a proposal to HaFei twice, and got support from the provincial government and the asset-holder of HaFei, AVIC (China Aviation Industry Corporation). However, HaFei's decision-makers refused these proposals, and insisted to the government and AVIC that they could continually achieve the growth of indigenous technological capabilities as they had already done.

(3) Huawei and ZTE

The intentions of Huawei and ZTE should be studied in particular contexts. In the early 1990s, China was experiencing a bubble economy. Public stock exchanges were opened as a new method of investment in 1990; the price of real estate also increased strikingly. Millions of people flooded into the newly opened Shenzhen Stock Exchange[77]. Many industrial firms transferred their working funds to the stock or real estate markets. The total amount transferred from the industrial sector to the capital market to pursue short-term profits reached several hundred billion RMB. A

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[75] The divide in opinion between central and regional governments is always a theme of China's economic development. Since Chery was invested in by local governmental agents, the regional government manipulated the regional transportation administration to issue licence-numbers as taxi-cabs for Chery's products within Wuhu City, from which Chery originated. Geely also had very limited sales within Zhejiang Province before 2001.

[76] The penalization of regulation could be very tough. Certainly, the execution would not be carried out by administrative orders directly. Instead, it would be implemented by legal methods, such as tax investigation as tax evasion was not rare among domestic firms. In 2004, a firm named TieBen violated the regulation of investments in the steel-making sector. The tax investigation upon TieBen came out with 294 million RMB tax evasions. The legal representative of TieBen was imprisoned; TieBen was re-organised according to the relevant laws and regulation.

[77] Huawei and ZTE are located in Shenzhen. There are only two exchange centres in China, Shanghai and Shenzhen.

number of Chinese high-tech firms joined this tide, and were even diversified by building up real estate subsidiaries, such as Stone and Lenovo in Q. Lu's study (2000).

In the face of intensive economic bubbles, Huawei still invested all it earned in the previous 5 years, namely around 0.1 billion RMB in total, to develop its large-scale PDSS in-house[78]. In order to raise the money for this project, ZhengFei Ren, the founder of Huawei, even borrowed money from an underground bank at 24% annual interest in his own name. In ZTE, the executive managers fought against the requirements from shareholders to enter multiple domains to pursue better short-term profits. In order to win a stable environment for product development, they signed a special agreement with the shareholders by which they promised to hand the fixed annual residuals over to the shareholders for exchanging managerial autonomy.

Their commitments to long-term technological capability building were also institutionalised through formal corporate regulations. In 1998, the "*Huawei Fundamental Law*" was announced as the basic code of mindset and conduct of this organisation, in which Huawei defined itself as a developer of telecom-equipment only (not for other diversified domains to pursue short-term returns), and to stimulate at least 10% of annual sales revenue to R&D. ZTE also formulated "*four fundamental rules"*, which required its members to focus on technical exploration and to build up the ZTE brand by competitive products.

5.3.2 Developmental activities: trajectories and pathways

Group-B firms also invested heavily in manufacturing lines, but these lines were principally built to serve their own schemes of in-house product development, not for localising the production of imported models[79]. Importantly, they kept developing in-house product platforms from their beginning. From this perspective, the trajectory of Group-B firms did not belong to either the traditional bottom-up or the top-down mode. They did not start from assembling or simply from basic S&T knowledge.

Considering the stage of industrialisation of China, it was inapplicable to domestic firms in most industries to start product developments relying on the local original S&T knowledge, especially in the 1980s and 1990s. However, unlike some other underdeveloped countries, China had established a comparatively complete industrial and research system during the 1950s-1970s, and had cultivated its own products in these industries. Besides the specialised engineering knowledge, there was experience of system integration embedded in the domestic industrial networks. The

[78] This decision caused divide of opinion. Two out of the three co-founders left Huawei. But this event also optimised the organisation of Huawei.

[79] Brilliant Auto, not a Group-B firm in a strict sense, was an exception. Before developing indigenous product platforms, Brilliant had already built up manufacturing lines to produce the *Haice* MPV model imported from Toyota. But it still had to construct new lines for its indigenous car models.

knowledge of this kind might be backward by comparison with that in developed countries. Nevertheless, it provided a basic sense of system integration for local elite engineers. After 1972, the emergence of foreign technologies in a massive manner in China provided the domestic industrial community with enlightenment about new product information, processing technologies, managerial approaches and global production specialisation, which in turn could be complementary to local experience. In theory, opportunities could be created by domestic practitioners to organise learning spirally by combining the indigenous experience with the newly obtained exotic technologies. Group-B firms were exactly such cases. To accumulate the knowledge for developing systemic products in their infancy, various methods had been employed to obtain knowledge from domestic and international sources.

To study competitive products was a popular method adopted by Group-B firms when they just entered this sector. However, this method did not mean to copy or simply imitate the competitive products although the simple copying of foreign products did happen to some poor-performing Chinese firms. Group-B firms had not detailed blueprints or other original data of corresponding competitive models. Rather, they analysed the competitive models on their own. These comprehensive analyses of competitive products provided guidance and reference for the trade-off of detailed designs of new product systems developed by Group-B firms. In their infant stages, when Group-B firms had not sufficient resources and capabilities to analyse a large number of competitive products, some details would be observed as similar to those of particular referenced products. In such situations, we name the benchmark(s) as the “target model(s)” of the designs of Group-B firms. For example, the first car model of Chery, the *Fulwin*, took the *Toledo* of SEAT as its target model. As the financial strength of Group-B firms increased, more and more references were included to study, and more and more local characteristics were created based on their integrative learning. Finally Group-B firms turned to obverse product development pattern when they had obtained sufficient capabilities.

The external technical cooperation was another important source of knowledge creation of Group-B firms in early phase. During their cooperation with foreign partners, the Group-B firms themselves worked as the integrators to make use of the external technical services that they outsourced, and took the cooperative projects as platforms for deliberate learning rather than purely a commercial method to acquire codified technical results.

Group-B firms all started their journeys from low-end markets by providing products with better performance/price ratio. In the car-making sector, the first-generation products that Group-B firms provided were often at only 1/2 or 2/3 of price of the mainstream competitive products in order to exchange the toleration of customers upon the comparative low-class qualities. As for the Group-B telecom-equipment firms, they started from market segments that incumbents did not care much about or had already ignored. The first product of GDT was a semi-digital PBX; for Huawei and ZTE, the first product models were both PBXs based on analogue technologies. Xinwei was the only exception. It entered this sector with the SCDMA standards of mobile telecom systems, which grew up from its laboratory and experimental emulative network. However, for practical commercialisation, Xinwei also started by providing services in peripheral market segments.

In general, even given their disadvantages with regard to resources, policy support and technological foundations, Group-B firms still managed to develop their own product platforms from their early stages on. They persisted with the strategic intent of indigenous product development. Capability-building has been implemented with activities of new product development.

5.3.3 Developmental activities: complete chain of product development

In addition to the manufacturing section, the Group-B firms had included most product developmental activities in-house. Certainly, considering the weak foundations of Group-B firms in terms of technological capabilities and resources, these activities were not all built in-house at once, but were developed by an evolutionary process.

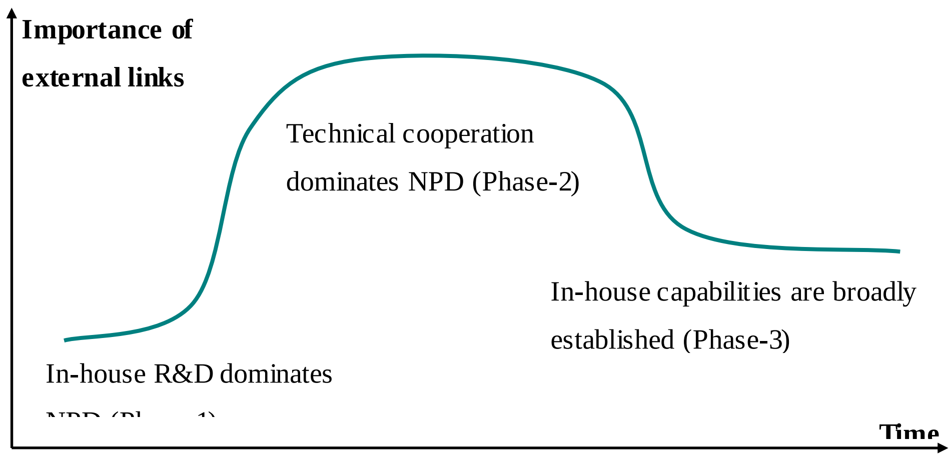
Certainly, we cannot cover all aspects of developmental activities in this thesis. Here we stress the relations between the in-house efforts and external cooperation, which provide a distinct contrast between Group-B firms and Group-A firms, and highlight the persistence of Group-B firms regarding the development of systemic products and complex technologies.

5.3.3.1 In-house learning and external cooperative projects

To implement the independent strategies for capability-building was not equal to being isolated from outside in term of knowledge creation. In fact, in the industries related to complex products and systems, seldom firms could include all developmental activities in-house for the products they produced, given the current globalised industrial circumstances. In addition to purchasing standard modules from the market, Group-B firms undertook external cooperative projects to obtain technical services and to facilitate their own technological learning.

The relation between in-house development and external cooperation of Group-B firms evolved over time, while the leading role of the in-house development during the integration was upheld. This process can be depicted by an inverted U curve into three phases. Phase-1 refers to the infant stage of Group-B firms launching their earliest product platforms aiming at mass-production. Phase-2 then refers to Group-B firms being gradually accepted by the domestic market and launching their second-generation products. Phase-3 is identified by their becoming competitive players in general in the domestic community. They launched their third and subsequent generations of products, and built up the capability foundations in-house to support sustainable obverse product development.

Figure 5.2 Evolution of the importance of developmental services outsourced of Group-B firms



In Phase-1, Group-B firms had to develop the products and subsystems mainly on their own since they were almost invisible to potential external co-operators. Only standardised subsystems and components could be purchased from market. However, this kind of market purchases might also be difficult to process. Suppliers usually required reliability from their customers, which was based on long-term trust, reputation and visible financial strength, since either the large volume supplies or the customised component development, would bring risks to the suppliers. Because of the inability to provide these conditions, products developed by Group-B firms in this phase were usually located at the low-end or low-level market segments for the limitations of supply chains they could access. The complexities of products and technologies were minimised for convenience. On the contrary, during this period, Group-B firms obtained the essential knowledge of different aspects of relevant technologies for product development since they had to develop many technical functions in-house on their own, and emphasized the breadth of knowledge within their small development teams.

In Phase-2, as the businesses of Group-B firms had been roughly established, the external co-operators and suppliers became more accessible. Group-B firms employed the external technical services and components to promote the qualities of products and to facilitate in-house technological learning. However, the newborn local firms were divergent in their learning patterns and performances during this phase. Some successfully built up in-house technological capabilities, while others failed. For the successful cases, they took external cooperation as guidance for in-depth knowledge exploration of in-house learning.

In general, after one generation of products development[80] in the third phase, the in-house knowledge foundations of Group-B firms for the sustainable development of systemic products and complex technologies had been set up. Certainly, the extent varied in different domains. For the knowledge that was difficult to handle at that moment, indigenous integrators established stable collaborative relationships with international suppliers, as also discovered by Brusoni, Prencipe and Pavitt (2001). But in general, several driving forces cause a transition to strengthen the dominance of in-house force from this phase: (i) the accumulative outcomes of learning, (ii) the desire to obtain a series of benefit brought by in-house development, e.g. cutting the costs of development projects, promoting the interchangeable rate of components, increasing the bargaining powers in external cooperation and increasing the capacities for design flexibilities, (iii) and the impetus of in-house developmental force for more power relating to resource allocation, which was indeed the fulfilment of their strategic intent.

Table 5.6 Evolution of the in-house development and services outsourced in Chery and Geely (-2008)

	Phase 1	Phase 2	Phase 3
Knowledge dimension	Pursuing the breadth of knowledge	Pursuing the depth of knowledge	Pursuing the breadth and depth of knowledge
Chery	1997-2002	2002-2006	2006-
Car models	S11, A11, A14, B11[81], etc.	S12, S21, A18, A21, B14, T11, etc.	T21, A13, A18, B12, B14, B21, M14, P11, etc.
In-house development	car configuration; chassis engineering; engines etc.	engines; die design	complete car development; new technical exploration
External Cooperation	die design	car configuration; engine design; chassis engineering; die design etc.	broad & general cooperation
Market Transaction	dies; engines; transmission; electronics	dies (*via* a JV); electronics	broad & general cooperation*
Geely	1997-2003	2003-2007**	2005-
Car models	*HQ/MR* series, *SMA* series, *Mybo-1*	*CK-1*, *CG-1*, *CI-1*, *LG* series etc.	*FC* series, *CD-1*, *GC-1*, *LC-1*, etc.
In-house development	car configuration, chassis engineering, engines, dies, etc.	engines; transmission; electronics	complete car development; new technical exploration
External Cooperation	very few	car configuration; chassis engineering; die design; Electronics etc.	broad & general cooperation
Market Transaction	engines; transmission; electronics	electronics	broad & general cooperation

[80] This usually took 4-5 years in successful Group-B firms in the car-making industry. It was no coincidence. Regarding international mainstream, commonly the cycle for a single car development is about 18-24 months from project initiation to SOP (start of production). Thereby, 4 years were sufficient for the same team to develop 2 product models in the same market segment with the foreign assistance (see the case of Chery in the table) which realised a twofold "exploration - deepening" process of the learning. If they implemented a parallel pattern of product development, 3 or more models could be developed in 4 years.

[81] For the car models of Chery, There are two named systems. One is the marketing, e.g. the *QQ* for the S11 model; the other relates the product in product series. For example, for S11, S means minicar (highly compact car, equals A00); 1X means it belongs to the first platform of A00; X1 refers to its sequence in this platform. From highly compact cars to luxury cars, there are six classes according to the vehicle length and wheelbase, i.e. A00-A0-A-B-C-F, plus T for SUVs, M for racers, and P for pickups. In this table, *S11* is for *QQ (3)*, *A11* for *Fulwin*, *A14* for *Cowin*, and *B11* for *Eastar*.

*Note *: "Broad & general cooperation" refers to such a status: Group-B firms have become comparative mature competitors in the Chinese market, and have already built in-house capabilities for most core fields, even varied in extent for different domains; external cooperative projects are to make use of international specialised forces, not as necessary and critical complements to in-house capabilities, which is similar to the strategies of international giants in implementing external technical sources in this industry.*
***: there was overlap between Geely's Phase-2 and Phase-3.*

Table 5.6 lists the evolution of in-house development, external cooperation and market transactions in Chery and Geely, which presents an inverted U curve for the significance of external cooperative projects to Group-B firms' capability-building. In the coming subsection, we present details of each phase to support our argument and explain their driving forces for shifts.

5.3.3.2 Phases in detail

(1) Phase-1

In their infant stage, Group-B firms had to rely on their in-house forces and the few suppliers they were able to assess. Comparatively simple models were developed for the limitation from both in-house technical capabilities and the limitation of external supply chains.

For example, for the development of *A11* (*Fulwin*), the first car model of Chery, the mainstream suppliers refused to participate in the development the customised components. Many of them also refused to produce those components that had already been designed by Chery[82]. Only several small firms and a few others that had good relationships with Chery for personal contexts agreed to share the risks.

The unfavourable situation of its supply chain even forced Chery to adjust the original design of *Fulwin* to utilise more existing components of *Jetta*, one of the "*Old Three*" models, which had a large supply foundation at that time[83]. Meanwhile, it introduced new suppliers into this domain. Its supplier of stamping dies was FuZhen from Taiwan. FuZhen showed enthusiasm as it was also an outsider to the car-making sector, but regarded this cooperation as a valuable chance to enter. In fact, FuZhen succeeded in this strategy and rapidly became a well-known stamping die developer in the Chinese automobile industry. It later attracted the orders from many other Group-B firms and even some Group-A firms.

At that time, situations for other Group-B firms were similarly difficult. It was even worse for Geely for the shortages of resources. It even had no automatic production line in early phase. People had to use handcart to connect different working procedures and maintain the production

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[82] In a latter case of the *Cowin* (*A14*) development, BMW accepted the request of Chery and supply engines based on existing models. But not surprisingly, it required Chery large amount of orders at once, which indicated BMW's indifference to long-term cooperation.
[83] Personal contexts of Chery's core members who had worked in FAW were critical to obtaining cooperation from these suppliers.

pace. Machines were mostly second-hand. Some metal stamping dies were even made from half-metal and half-synthetic resin to save costs! Moreover, Geely even had no CAD (Computer-Aided Design) capability when it had already launched its first car model. Without doubt, it was reasonable for leading specialised suppliers being indifferent to such car-maker. Therefore, in its infancy, Geely had to persuade the local suppliers of its motorcycle value networks to enter the car-making sector, which were also 100% newcomers to this industrial domain.

In addition to the unfriendly attitudes of suppliers, Group-B telecom-equipment firms moreover had to face the strict embargo regulated by COCOM (Coordinating Committee for Export to Communist Countries) before 1994, which isolated the Chinese mainland from high-tech products and services from relevant countries. Among the prohibited goods, high-end IC chips and high-precision processing machines were particularly significant for them considering the weak domestic semiconductor and relevant industries at that time. The traditional centralised structure of PDSS systems required precisely high-end IC chips with strong data-processing capacities, but these chips were inaccessible to Chinese developers. However, the difficulty also induced some Chinese developers to explore the new decentralised technical architecture of product systems by themselves. For instance, when CIT developed the *HJD-04* model, what they could get were standardised chips with small data processing capacities such as the *No. 244*, *No. 245* and *No. 374* chips. Even for these chips, engineers of CIT could buy them only from the bulk cargo market of Shenzhen that was a special economic zone of China and had some informal merchandise inflows from Hong Kong. Nevertheless, CIT did succeed in developing the *HJD-04* system with these standardised chips, in which the chips that worked as data-processing centres for most modules were the *Motorola-68000*, also a low-end chip.

(2) Phase-2

In Phase-2, Group-B firms had been recognised as promising attackers in their industries for the commercial successes of their first-generation products in the last phase. This changed their external circumstances, especially the attitudes of foreign specialised technical firms that were looking for business opportunities in China.

HaFei was the first-mover to employ international technical services for its in-house product development in the Chinese car-making sector. The cooperation between HaFei and Pininfarina (Italy) started in 1995, in which the foreign side accepted to provide the bodywork styling service for an independent product development project from HaFei. This pattern was quickly identified by other indigenous firms that were also searching for practical ways to utilise external technical resources. Chery and Geely started to cooperate with international technical companies from 2001, the first year they were officially allowed to enter the car-making sector.

TextBox 5.2 Cooperation of HaFei with Pininfarina

Pininfarina began to seek potential co-operators in China from 1993, as its profit-making capacity was depressed by the downturn of the global automobile industry. Pininfarina regarded HaFei as an excellent candidate for its motivation for implementing product development and digitalised design capability that was transferred by HaFei from its aircraft-making division and was remarkable in the Chinese domestic automobile industry at that time. Pininfarina initiatively proposed a project to HaFei in 1995, which was to develop the bodywork for a minibus model, namely the *ZhongYi*. HaFei developed the chassis and other subsystems on its own, based on its capabilities accumulated during the preceding 12 years.

At the beginning, Pininfarina wanted to practise it as a turnkey project in spite of the agreement it had made to open the developmental process to HaFei. In Italy, Chinese visiting engineers were forbidden to enter the areas where real developmental activities were going in. They were allowed to witness the development outcomes only when periodic blueprints came out. It certainly was not what HaFei expected. The Chinese side took the contract as the weapon, and threatened to cease the cooperation. Pininfarina had to accept HaFei's request and let Chinese engineers participate in the developmental process. For learning, HaFei had in total sent over 100 engineers to Italy in this project, despite its severe limitations in finance.

The *ZhongYi* prototype was launched in 1998 successfully. After that, HaFei established more partnerships with external technical partners for its product development. In developing the *Lubo* model, Lotus (UK and Malaysia) was in to provide the engineering optimisation for the chassis. HaFei also cooperated with Mitsubishi in the *SaiMa* project and with Tjinnova (China) in other projects.

The external cooperation promoted capability-building in HaFei. In 2003, HaFei launched a new minibus named *MinYi*, which was developed mainly by in-house engineers, and proved the growth of their capabilities.

We cannot list all projects involving external cooperation of each Group-B firm during this phase, since they were large in number, and were documented in different categories according to the mode or extent of cooperation. Therefore, we just present the prominent cooperative projects of Chery ongoing in the year of 2005 in Table 5.7.

Table 5.7 Important outsourcing cooperative projects of Chery in the year 2005

Cooperative partner	Projects	Location of cooperation	Start date
AVL (Austria)	ACTECO Engines (including 3 families, 18 models)	Both sides; according to plan	2002
Bertone (Italy)	Car configuration	Both sides; mainly in Italy	2002
I.de.A (Italy)	Car configuration	Both sides; mainly in Italy	2004
Pininfarina S.P.A.	Car configuration	Both sides; mainly in Italy	2003
IAT (China)	Car configuration	Both sides	2003
Torino Design (Italy)	Car configuration	Both sides; mainly in Italy	2004
MIRA (UK)	Chassis engineering; testing & adjustment	Both sides; according to plan	2002
Lotus	Consulting; testing & adjustment	Both sides; according to plan	2002
Ricardo plc (UK)	Hybrid power tech; Transmission	Both sides; according to plan	2004
Dürr (Germany)	Paint shops	Both sides; mainly in China	2002
MAG Hüller Hille (Germany)	Production line of engine cylinder	Both sides; mainly in China	2002

Note: data are collected by author, and these are far from being complete in number. In particular, most projects related to the development of components and processing technologies are not included.

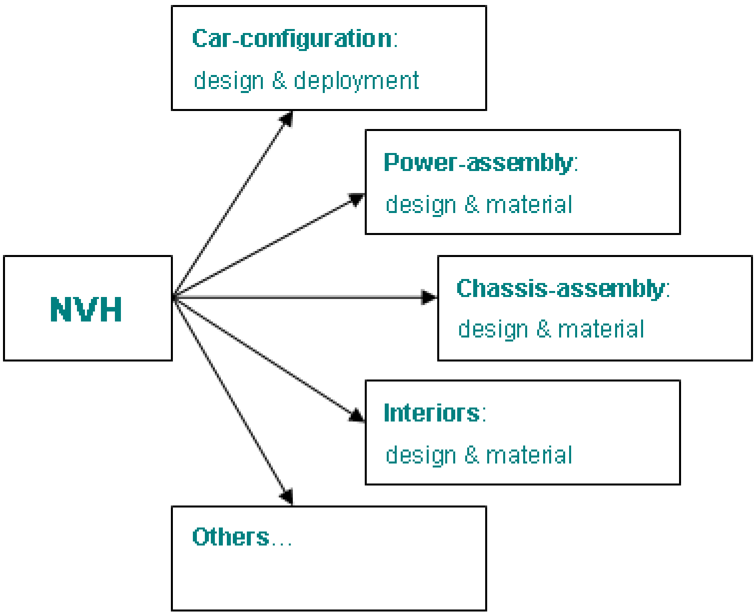
In the telecom-equipment sector, Group-B firms could not access the foreign technical service providers in most cases before 1995 as they were obstructed by COCOM, but they cooperated with domestic research institutes and universities. By these projects, they employed and re-integrated the intellectual resources accumulated by the R&D divisions of previous branch-based industrial systems. Huawei and ZTE had once cooperated with almost every institute affiliated to the former MPT system during 1980s-1990s.

Group-B firms gradually worked out the mechanisms to ensure the learning activities really co-operated with the external partners as expected. In most cases, external co-operators were not motivated to help Group-B firms to build up in-house capabilities. Rather, they were likely to prevent this for their own future benefit. Thus, the practices of learning from external co-operators were not like the "teaching and learning" in classrooms, but like a tug-of-war. Original contracts of cooperative projects were the most frequent applied weapons used by Group-B firms to have external co-operators to open the developmental processes for engineers from Group-B firms to learn, as exhibited by the HaFei-Pininfarina case. As Group-B firms became experienced in or through external cooperative projects, they made the contract drafting a developmental process led by engineers rather than just business negotiators. The effectiveness of contract clauses as weapons was achieved not only because of the hunger of the foreign sides for business, but also for the insistence of Group-B firms. As the strategic intent of Group-B firms prioritised the learning beyond simply getting well-established products for manufacturing, they did show their decisiveness to suspend or even cancel ongoing projects if what foreign sides did damaged the core value of cooperation for them. Their insistence did push foreign sides to perform as scheduled in the contracts. Besides, with the growth of in-house technological capabilities of Group-B firms, more and more cooperative projects were arranged to locate in the places of the Chinese sides. This enhanced the ability of Group-B firms to control the process and enable them to invest more personnel to participate in and learn from the cooperation.

When employing external cooperation, Group-B firms had not stopped in-house capability-building. During Phase-2, most Group-B firms had established and expanded specialised technical departments. The developmental activities of experienced co-operators were closely traced and taken as the appropriate direction for deepening and broadening the knowledge accumulation of in-house engineers, and as the direction re-constructed their organisations accordingly.

Chery's learning in regard to NVH (noise, vibration and harshness) control of car development was a good example. The control of NVH was important for high quality car-making. However, prior to Phase-2, Chery's engineers had not acknowledged this concept, which meant that the first-generation products of Chery did not engage with any NVH control. Considering that most of Chery's core engineers were from Group-A firms and from other vehicle-makers, this indicated that the concept of NVH control for car development had never been unfolded in the domestic community including Group-A firms.

Figure 5.3 Knowledge domains closely relevant to NVH control



This concept was introduced by Lotus unintentionally to Chery when Lotus advertised another service to Chery through a presentation. Chery's engineers seized on this unfamiliar but possibly important concept and tried to dig deeper. Finally, Lotus agreed to make a paid presentation for its potential customer. The presentation brought about a critical concept related to systemic optimisation of products, entailing a wide chain of relevant knowledge for domestic engineers to learn (as in Figure 5.3). After obtaining this guidance, Chinese engineers themselves carried out detailed explorations, and they re-structured their technical departments according to the new cognition that they developed evolutionarily through the cooperative projects.

(3) Phase-3

In Phase-3, the learning activities of Group-B firms largely stopped centring on external cooperation, which did not mean the decrease of cooperative projects in absolute amounts. The number of cooperative projects still increased, but external cooperation did not play the influential role in scheduling product development as before. Gradually, external services were employed only as needed as specialised assistance to Group-B firms' in-house developers rather than a "master" to lead the process. Critical parts of product development were changed to be developed in-house again. The new phenomena emerging in this phase concerning the relations between in-house development and external cooperation can be put into three categories.

Firstly, the location of cooperative projects shifted more to Group-B firms. Consequently, external co-operators more turned to providing specialised consultancy or packaged services; and Group-B firms could invest more personnel to the relevant development and learning activities. For example, Table 5.8 demonstrates the evolution of cooperation between Chery and AVL, which was aiming to develop 3 series including 18 engine models.

Table 5.8 Chery's Cooperation with AVL in development of engines (2002--2008)

Phase	Models developed	location	Role of AVL	Time period
1	4	Mainly in AVL	Dominant	3 years
2	3	Mainly in AVL	Supervisor	
3	11(18)*	Mainly in Chery	Consultant	4 years

Note: another 7 models were added in the third phase mainly by the Chinese side.*

Geely also realised the change during this phase. It even began to dominate cooperative projects for external requirements. In 2005, the Hong Kong Productivity Council proposed a cooperative project with Geely to build a car model aiming to promote the auto component industry in Hong Kong. The Hong Kong side invested heavily in this project and organised the suppliers, but the leading role of this project attributed to Geely since no Hong Kong participant could replace Geely's functions of technological integration and systemic product development.

As to the telecom-equipment sector, the alliance between Huawei and 3Com exhibits exactly Huawei's growth of capability and its change of role regarding external cooperation[84]. A productive JV named H3C was established in 2003 by these two firms. The core products of H3C, namely the *SR8800* series routers, were secondarily developed based on Huawei's existing models.

[84] Here, it is helpful to point out Cisco's lawsuit against Huawei in the name of Huawei's "allegedly counterfeiting" its IPRs which happened during the Huawei-3Com negotiations in 2003 (Cisco was the incumbent in the data communication equipment market, facing the attack from Huawei). In this case, 3Com went to the witness stand for Huawei, and testified that Huawei really had built up relevant capabilities for developing the products sued by Cisco. Prof. Dennis Allison of the Stanford Univ., who was invited by the court to act as the third-party attester as a communication technologist, also testified that for the same technical function within Huawei's VRP model and Cisco's IOS model in question, Cisco employed 20 million lines codes while Huawei only employed 2 million. So he denied that Huawei would copy or imitate Cisco's codes. Finally, Cisco withdrew the accusation in 2004.

In fact, those existing models were valued by 3Com as a major part of Huawei's investment in this JV. Former Huawei engineers played the leading roles for R&D and post-sales services of H3C, with a total number of employers over 1,000 whereas there were only 50 from 3Com. The situation even continued after Huawei sold its all shares of this JV to 3Com. Besides, Siemens also manufactures Huawei's digital network products *via* OEM for the European market.

Secondly, some previous external cooperation had been replaced by in-house projects or by projects contracted to affiliated firms. A series of first-tier suppliers had been established by Group-B firms. For example, the number of first-tier supportive firms owned by Chery was over 30 in 2006. International leading suppliers also established JVs or cooperative plants for Group-B firms. These affiliated supportive firms had covered most critical sections of the supply chain (see TextBox 5.3), and had "permanent" or "quasi-permanent" relationships with the Group-B firms.

TextBox 5.3 Affiliated supportive firms of Chery (data from 2007)

The surge of establishing affiliated supportive firms started in 2004. Three kinds of firms were invested in by Chery to exploit different sources of knowledge. They included those firms spun-off from the growing in-house capabilities of Chery, those ventures established in China by Chery and external technical experts from universities, public research institutes, overseas, etc., and those ventures established by Chery in overseas to make use of foreign R&D capabilities, such as Chery's subsidiary for transmission in Australia.

Some of these affiliated firms became successful very soon. For instance, Bonaire, the affiliated air-conditioner developer of Chery, had already covered 80% of Chery's procurement of air conditioners. It also seized about a 30% share of the entire domestic market. ATECH, the affiliated instrument and meter provider of Chery, had occupied 100% R&D tasks of relevant parts of Chery, accounted for 80-100% of Chery's real usage, and reduced costs of relevant components by 50%[85], which was also an important contribution to the whole domestic sector. TROITEC was a provider invested in by Chery to provide the Engine Management System module. Now, it provided services for 20+ domestic car-makers, including many Group-A firms.

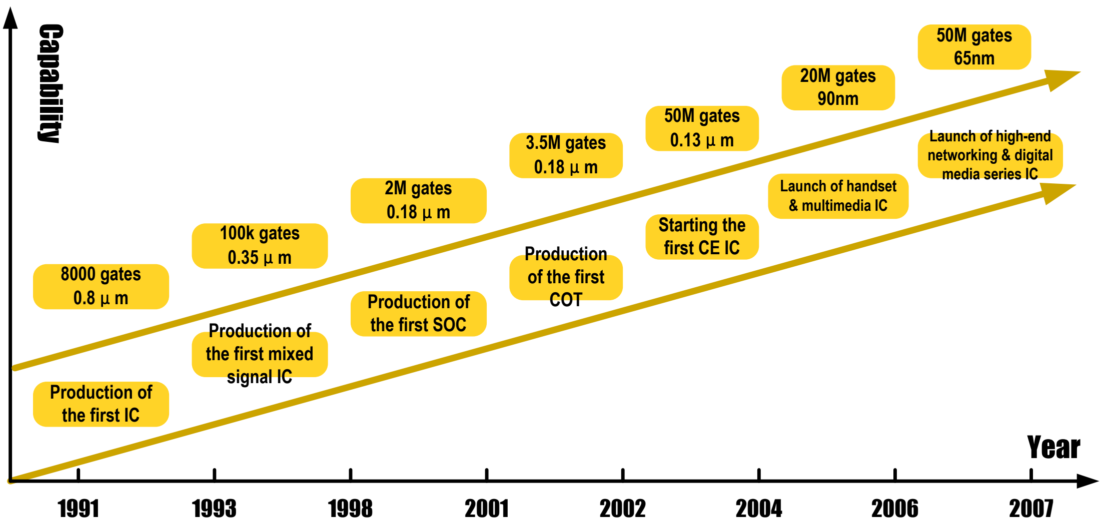
In the telecom-equipment sector, we can take the LSI chip as an indication: in Phase-2 (after 1994), Group-B firms had to request LSI chips from international specialised chip developers, such as Mitel, Texas Instruments and STMicroelectronics. This obviously limited the space for indigenous developmental activities. Based on the outsourced chips, what Group-B firms could do was to develop their solutions and corresponding architectures of the system, to develop software and peripheral ASICs. However, as they persisted in capability-building, in Phase-3, Group-B

[85] For example, the price of the instrument and meter set for *QQ* (S11) was 400 RMB/set when Chery purchased it from outside. Now ATECH can provide it at 200 RMB/set and lowers the price for the whole domestic market. Many other firms have been its customers, including some Group-A firms.

firms had been able to develop LSI chips and other critical modules in-house, which promoted their creativities of product development and strengths in response to market demands.

Figure 5.4 presents the capability growth of Huawei in the domain of ASICs, carried out mainly by HiSilicon, which was founded in 2004 based on the ASIC department of Huawei established in 1991. For a long period, HiSilicon could only develop peripheral chips. However, with the persistence of learning efforts, HiSilicon could produce major ASIC chips from 1998. The change enabled Huawei to develop beyond its former follower strategy of product development (by following the directions of international frontier firms) toward actively self-determined product innovations. From around 2000, chip development was no longer the weakness of Huawei's capabilities. Rather, HiSilicon started to diversify the categories of chip development to employ its capability for benefits around 2004, and began to provide the services for other firms.

Figure 5.4 Rapid development of the specialised ASIC subsidiary of Huawei



Note: the top row represents design capabilities, represented by the scale of chips per unit and the level of precision; the bottom row represents the technical milestones and the new domains it successfully explored.
Terms: SOC: System On a Chip; COT: Customer-Owned Tool; CE: Consumer Electronics
Source: HiSilicon Tech.

Thirdly, in-house technological capabilities rapidly increased. For the sake of brevity, we skip the description of their growth in each field. Instead, we emphasize their abilities of long-term technical exploration, which were achieved by the central R&D centres of Group-B firms, which were usually spun-off from their product development divisions.

In the car-making sector, the number of patent applications by Chery ranked the 2nd in the Chinese automobile industry from 2007 (note that MNCs also applied patents in China to protect their technologies and products), and the 1st among Group-B firms.

Table 5.9 Patent application of Chery (2006-2008)

	2006	2007	2008	Grand total (2008)
Total applications	631	1058	1099	3197
Includes: patents for inventions	127	244	412	805
Granted				1671

As for Geely, a series of high-end subsystems had been developed in-house, including the EPS (Electronic Power Steering) and the CVVT (Continuous Variable Valve Timing) engine before 2007. The progresses enabled Geely to adopt high-end subsystems in low-price cars. By 2007, Geely had been granted 417 patents. In 2008, Geely's original technology named "Blow-out Monitoring & Brake System (BMBS)" was announced at the Detroit Auto Show and was awarded a "*Special Contribution Grand Prize for Invention and Creation*".

The progress achieved by Group-B telecom-equipment firms was more remarkable. As reported by WIPO (World Intellectual Property Organisation), Huawei was ranked as the 1st applicant under Patent Cooperation Treaty (PCT) in the world in 2008. ZTE was ranked the 38th in 2008 with 329 applications published. With these patents, Huawei and ZTE had already become core members of alliances for frontier technologies, including the alliances for WCDMA, CDMA2000, WiMax, LTE (Long Term Evolution), etc[86].

Table 5.10 Patent applications from Huawei (2005-2008)

	Each year				Grand total		
	2005	2006	2007	2008	2006	2007	2008
Total application					19187	26880	35773
Includes PCT	249	575	1365	1737			
Granted					2742	4256	

Data sources: For PCT applications, data are collected from WIPO; for the rest, data are from interviews and annual reports from Huawei.

5.3.3.3 Divergence of new indigenous firms

As we have indicated, it was wrong to state that all newborn local firms would succeed in in-house capability building. The building of their organisational learning systems has to experience a "*cognition – selection – implementation*" process, during which divergences could occur. As a result, some of them failed, or met significant difficulties.

In the telecom-equipment sector, there were over 200 newborn domestic firms entering this industry during the late 1980s and the early 1990s. Many of them experienced difficulties to catch

[86] Huawei had 156 kernel patents of WCDMA (data from 2008), occupying about 7% of all kernel WCDMA patents owned by members of the 3GPP (3rd Generation Partnership Project), and was ranked the 5th in the world. As for LTE, by 2008, Huawei had already submitted over 900 technical proposals to 3GPP, and over 550 technical proposals to SAE (System Architecture Evolution). In 2009, Huawei and Nokia shared the first LTE networking construction in the world (in Sweden). As for CDMA series standards, Huawei had more than 1200 related patents. About 400 of these were critical in the global community, and 40 of these were kernel. For WiMax, ZTE was one of the 15 directorate members of the WiMax Forum, which was the core for WiMax technological communication and IPR trading. Huawei had principal membership of the WiMax Forum, and had over 100 WiMax related patents (data from 2007).

up regarding the development and commercialisation of large-scale PDSS, which mirrored the non-effectiveness of their learning or relevant organisational changes. Until 1998, most of them had been cleared out as well as the poorly performing Group-A firms by tough competition of the price war of PDSS raised by Huawei, ZTE, JinPeng and Shanghai-Bell. In the car-making sector, many new entrants also failed to build effective organisational learning systems. To be specific, they just took the wrong way. Witnessing the triumph of HaFei, Chery and Geely in exploiting international technological resources, they also tried to cooperate with external technical companies but turned out to rely continuously on external technologies. More than 100 new firms rushed into the car-making sector in 2001[87]. During 2003-2005, in the segment of SUV-making alone, there were over 30 new makers that adopted the same stamping dies set (with the body design embedded) provided simultaneously by the same firm from Nanhai City. Only if the domestic firms had basic capability of manufacturing truck chassis, could the provider, with technologies from Taiwan, give them a solution, namely the "*stamping dies and embedded bodywork design plus the in-house chassis of customers*", to launch an SUV model. However, the reliance on external technologies made these firms incapable of surviving the product-oriented competition. After 2005, most of them had been washed out.

Two cases are analysed to reveal how different cognitions led to different trajectories of organisation building, and then to divergent learning performances. Both firms had had successful experiences: Brilliant succeeded in localising the production of *Haice* (an MPV model) from Toyota in the 1990s; GDT was well known for its success in developing the *HJD-04* model. They also had strong financial commitments to new product development. Nevertheless, they still met great difficulties in their further learning journey. Brilliant had its product platform mainly rely on outsourced technologies and services. The member units of GDT still believed in the relation between the R&D and production of the previous command economic system. Their cognitions led them to wrong selections and constructions of organisation building.

(1) Case of *ZhongHua* series, Brilliant Auto

The ZhongHua series was initiated by Brilliant in 1997, with *M1* as the first model. It was a well-known failure in developing the indigenous products by employing external technical resources.

A group of financiers dominated Brilliant before 2003. The engineers, except for heads of production bases, were excluded from the team of executives. With regard to indigenous capability building, these financiers emphasized the possession of brands, IPRs and production

[87] Because the regulation of car-making has been transferred to an "*ex-post approval*" system, we cannot find exact statistics from the government about how many new car-makers crowded into this sector around 2001, since many of them failed in just a few years. But the crowding-in of new entrants could be verified by interviews, and by those rarely-heard car brands we can discover in domestic second-hand car markets even today.

capacities, which could be "measured" by their financial methods. Therefore regarding the process of technological learning, they were delighted only to see codified outputs, no matter how and whence the outputs came. So they naturally regarded making use of external technical resources as a promising method. In detail, the body styling and systemic configuration of *M1* were developed by Italdesign (Italy), and the chassis was developed based on that of the *Galanz* by Mitsubishi. Three firms from Germany, namely TRW, ZF, and Lemforder, were contracted to develop the brake, steering, and suspension subsystems respectively. MIRA provided the general testing for the prototype. Another four firms from Germany contracted the planning and construction tasks of production lines: Schuler for the metal stamping workshop, KUKA for the welding workshop including all robots, Dürr for the painting workshop and Schenck for the final assembly workshop. Besides, ITCA (Italy) was contracted to develop critical stamping dies.

However, because of the marginal position of the in-house technical and engineering personnel in the decision-making of Brilliant, they had few opportunities to touch their "own" product model before the product design was finally delivered onto production lines. During Brilliant's negotiations with foreign contractors that were indeed highly technology and engineering related, the in-house engineers were excluded on their own decision-makers from the delegate team, or just worked for checking and receiving the data from foreign sides when the contracted tasks were finished. Thus, the engineers of Brilliant had no chance to learn through these cooperative development projects. After the model was delivered, they were just treated as operators of different specialised divisions of production lines. Here, the executives of Brilliant were just duplicating their successful experience in localising the *Haice* model; and they thought that the "product technology (IPRs and brand) plus production" strategy could naturally bring about technological capabilities with the day-by-day operations of in-house engineers.

However, the negative consequences emerged: in 2000, the first lot of *M1* cars were found to have many problems, including severe off-tracking. Even insiders conceded that "*the quality was as bad as [that of] products crudely made by amateurs*"[88].

In the face of these unexpected difficulties, in-house engineers were firstly expected to fix them. However, since they were 100% new-hands to the newly delivered product model and newly delivered production lines, they did not have the capability expected by the executives. In fact, even though in-house engineers were supposed to fix these problems, they had very little influence over strategic resource allocation in practice.

The disappointed decision-makers attributed the failure to the low quality of domestic engineers. Then a solution was made to apply high-quality technical work forces by employing more and

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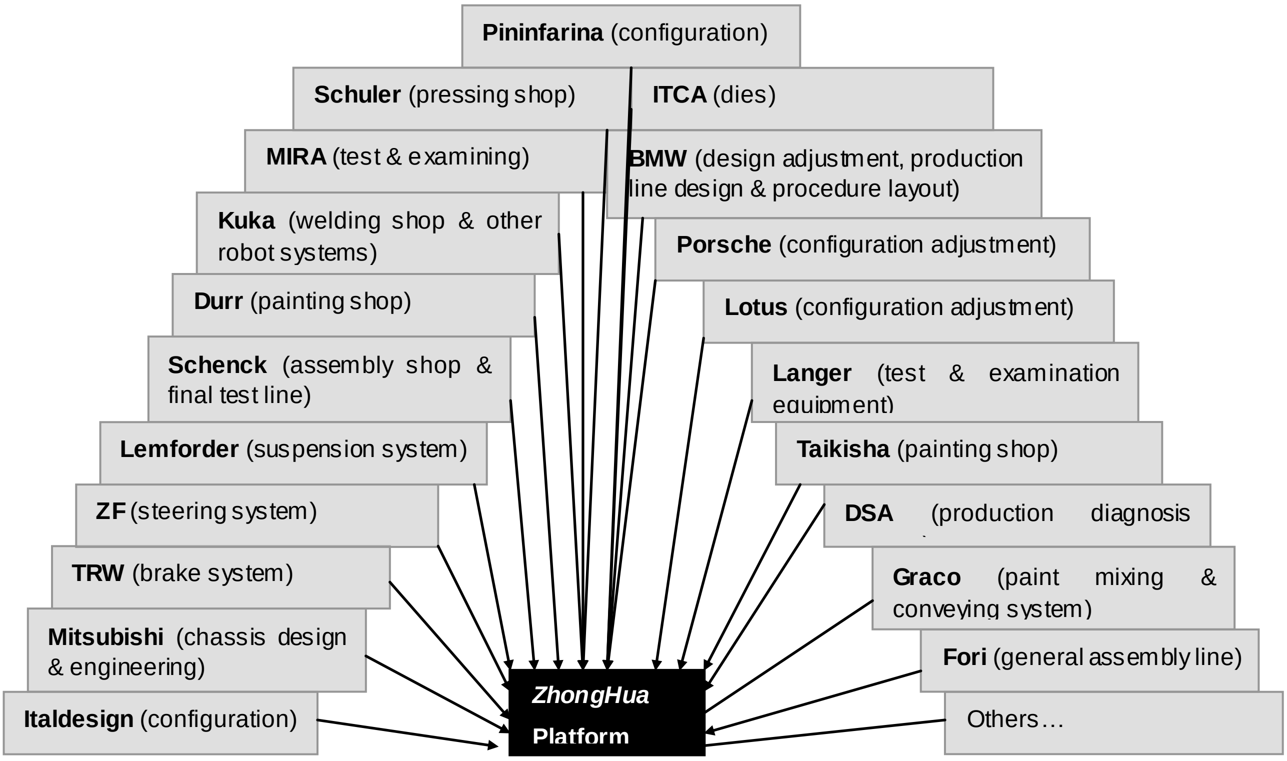
[88] Interviews with Xiaogang Lin, Zhigang Liu and Yong Ding, 2005.

"better" foreign aid. During 2000-2004, Brilliant implemented three rounds of significant revisions to the *M1* model. Huge financial resources had been expended purchasing services from international technical firms and supplementary equipment. By 2005, the *ZhongHua* series project had already cost 4 billion RMB. However, the *M1* still had not succeeded in satisfying customers as a technically appropriate car, except that Brilliant had made a very long list of foreign contractors (see Figure 5.5).

Figure 5.5 Foreign Contractors Involved in developing *ZhongHua M1* (1997-2005)



Note: ***Taikisha****: a Japanese equipment provider;* ***DSA****: a German equipment provider;* ***Graco****: a U.S. equipment provider;* ***Fori****: a U.S. equipment provider; Langer: a German equipment provider*

During this process, although in-house engineers had seldom been given opportunities by executives to participate in critical development projects, they were punished for their "inborn" unsatisfactory performance – a financier was appointed to head them. However, in fact, it was exactly the absence of in-house capability building that led to the failure to integrate the external technical services. Considering that external contractors all focused on maximising the technical performance of their perspective fields, there was no in-house actor to coordinate and integrate outsourced services. Rather, since outsourced tasks were highly specialised, and in-house engineers had not been arranged to participate in or even witness, the outcomes of external contractors turned out to be opaque to in-house engineers and other contractors. This increased the inclination of each contractor to maximise technical requirements in their respective fields to ensure liabilities, and promoted the systemic complexity for anyone to understand it, even no mentioning the tacit knowledge embedded by each side.

The situation changed only after 2004. In that year, financiers lost their control, and the new authority hired FuQuan Zhao[89] as a senior vice president to lead the technical and product development. He implemented a series of organisational reforms, including enhancing the professional R&D teams and promoting the status of engineers, most of which can be found in our analyses of Group-B firms' organisational system in the next chapter. Critically, the reform had the in-house engineers supervise the process of outsourced projects, and control the resources allocated to foreign partners and time schedules. By doing so, effective platforms of technological learning for in-house engineers were gradually constructed.

The reform achieved remarkable results. New models were launched in 2006, namely the *M2* for the car segment and the *Granse* for the MPV segment. The significantly improved qualities began to re-build the reputation of Brilliant (see Table 5.11).

Table 5.11 Car sales of Brilliant, Chery and Geely during 2003-2007 (Unit: 1,000 sets)

Year	2003	2004	2005	2006	2007
Brilliant	25.6	11	9	58.1 (M1/M2=25.5/32.6)	115 (M1/M2=32/82)
Chery	90.4	86.5	185.6	272.4	381.2
Geely	75.8	96.7	149.9	204.3	217.7

In sum, the evolution of Brilliant proved that resource investment and foreign technical aids would not definitely bring about technological capability growth. It was the reform, entailing organisational changes as core components, which bring about the critical difference of outcome.

(2) Case of GDT

HJD-04 was the first large-scale PDSS developed and industrialised successfully by the Chinese. Its technical development was undertaken by CIT. Before transferring into the telecom domain, CIT was specialised in researching computer technologies as a military unit. Core members of CIT had participated in governmental and military research programmes since the late 1960s, including the development of the first indigenous computer based on IC technology (*J101*, begun in 1972) and of a mega computer project (*H103-II*, begun in 1976). CIT itself had developed a mega-computer for military users called *DP300*, which was based on a distributed mode of technical architecture. This mode could improve the computational capacity of the computer with relatively weak and small-scale IC chips. It was exactly the distributed mode they carried on that helped *HJD-04* break through the inability of the domestic IC industry to provide large scale chips, and developed *HJD-04* into a technically frontier matrix-distributed structure[90].

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[89] Zhao had worked as the director of research at Daimler-Chrysler's R&D centre. Zhao's reputation helped him to carry out these reforms in Brilliant.

[90] To be specific, in the *HJD-04* system, the CIT adopted the "*500 million basic floating-point operations per second*" technology they had developed in the computer domain. And the advanced technical features of *HJD-04*, even regarding the global industrial community, could be presented as its '*level-wise distributed controlling structure*' and '*replicated*

Therefore, the developers of the *HJD* series had experienced technical successes in the previous command economic system, and such technical successes worked to their triumph of *HJD-04* significantly. It very possibly enhanced their belief about organising R&D activities as in the previous industrial system. CIT and other member units of GDT did make this mistake.

After launching the *HJD-04* model, GDT was operated as a tight alliance during 1992-1994: PTIC was the major financial investor and coordinator of the alliance; CIT worked as the technical centre; and the experiment factory of CIT, four MOEs affiliated to MPT worked as manufacturing units. Moreover, in 1995, the alliance built up a formal industrial group: in addition to the members of the alliance, two MOEs affiliated to the Ministry of Electronic Industry and one MOE affiliated to the military joined in. However, during 1995-2001, GDT was still a loose industrial group and member units had independent financial accounts and rights.

Even though managerial autonomy was largely attained by this newly established firm, the R&D side and the manufacturing side within the firm still followed the coordinative pattern as in the command economic system, although there was no authority forcing them to do so. The member units had not updated their cognition about the dynamic relationships between R&D, production and marketing. As product technologies were regarded as free goods to producers in the central planning economy only if planners had made corresponding arrangements, PTIC kept this legacy informally to some extent, and offered the technologies of *HJD-04* free to 4 subordinate factories. Later, 5 more factories were allowed by PTIC to join GDT as relevant ministries and regional governments appealed to it in the name of saving these poor-performing SOEs. In fact, the loose IPR control happened to almost all members. Then finally, there were over 20 SOEs in practice producing *HJD-04* contemporarily although some of them were even not supervised by GDT. *HJD-04* providers even competed against each other in the market.

Regarding the investment in R&D, the manufacturing units were reluctant to raise for CIT, because in the previous central planning system the regular funds for R&D specialised institutes were allocated directly from the government, and were separate from that for the manufacturing division. With the coordination of PTIC, members all accepted that as a company in the new market-oriented circumstance they had to learn to organise R&D within their own industrial group. In other words, they should be self-organised to feed their own R&D division, i.e. the CIT. Finally, they worked out one flexible method to decide the annual fee according to probable sales of each in the last year. Therefore, the fee was somewhat quasi-"*production licence royalty*" for the developer of technologies, i.e. CIT.

CIT was also influenced heavily by the legacy of the central command system. It still acted as a

T-type switching network', which were GDT patents granted.

research institute fully funded by the government regardlessly[91]. Its strategies were set to maximise the technical targets appointed by the top-down order (previously by the governmental industrial administration, now on its own decision-makers or by the government-funded projects), not the connections with the manufacturing division or the visible demands of customers. Supported by the State Science and Technology Commission, CIT built up a "National Digital Switching System Engineering and Technology Research Centre". A series of frontier technological explorations were carried out as parts of national S&T programmes, without carefully considering the commercialisation aspects. These projects included the development of advanced intelligent networks, a super large-scale PDSS, the CDMA application, the radio network controller of 3G mobile, the LSI chip, etc. For its achievements in long-term technical exploration, CIT were honoured with a series of governmental awards.

However, in spite of these awards, CIT had not provided effective incremental improvement and new product development for the GDT. In 1996, one bug in the *HJD-04* system was discovered but GDT could not generate a quick consensus or a course of action among its members. Especially, the funds of CIT had been almost totally occupied by its technical exploration projects. Meanwhile manufacturing units were reluctant to do or to fund this task[92]. So the technical bug was not solved soon, which caused dissatisfaction among telecom operators. Finally, the expanding negative effects of this bug acting upon the telecom network turned out to be intolerable to the industrial regulator. MPT announced an administrative order in 1996 to suspend the business of GDT for a 9-month rectification. After the prescribed period, GDT did succeed in solving this technical problem through funding CIT for a solution, but did not succeed in generating internal cohesion among members to respond to the emerging product-oriented competition. Meanwhile, new indigenous firms, like Huawei, ZTE and JinPeng, raised a price war on PDSS. These firms provided intensive post-sales services and derived products. Thereby, GDT in fact opened a "window of weakness" towards competitors and became fragile to the new competition. More importantly, it never fixed its organisational mobilisation problem. As JiangXing Wu, the leader of CIT, admitted GDT was more like a club for money collecting and splitting than an integrated enterprise, and every unit just cared about its own benefits[93]. After the bug event, GDT never recovered its leading role in the domestic telecom-equipment industry. In 1998, the military side quit GDT, clearly announcing the failure of GDT's previous pattern.

[91] In fact, the reason for CIT's transformation into the telecom industry was exactly because the government could not fund it efficiently as before. From the early 1980s, large-scale disarmament was carried out to cease opposition with the West for China getting well with the capitalism camp. Therefore, the military S&T system was expected to be reformed, and military technologies were expected to be transferred for civilian use, for saving the state expenditures in relevant fields. That was why CIT had to search for new applications for their technological competences.

[92] In fact, for the reluctance of the manufacturing units, the fees they paid to CIT were not sufficient for CIT's expenditure. To raise money for its R&D behaviour, CIT insisted from 1992 on having its own experimental factory the right of producing and selling the *HJD* series of products.

[93] Interview with JiangXing Wu in 2004.

The failure of GDT manifested problems far beyond resources. It once had excellent products and technologies, an excellent R&D team, excellent manufacturing units (backbone SOEs and PTIC that had the largest mobilisation capacity in its industry), and even a market advantage: up to 1997, there had been over 10,000,000 lines of *HJD-04* installed in the Chinese telephony network, with more than 4000 C3-C5 switching centres. The operational management also could not simply be blamed because for each unit it was good. The failure primarily resulted from a misleading understanding about technological learning under the new circumstances. With that understanding, GDT could not translate its strategic intent into effective organisation by integrating the R&D and manufacturing units and responding to the emerging product-oriented competition. Their cognition might be invisible, but difficult to change. Even in 2004 Wu still believed that if he attracted more financial resources at that time, or if factories could espouse a greater commitment to the collective benefit (and listen to the CIT), he could fix all technical problems associated with GDT; then, GDT would be on the proper road to sustainable success.

5.4 Analysis: contrasts between the two groups of firms

In this chapter, we have already analysed the developmental activities and strategic intent of the studied firms. These two dimensions are highly interconnected because the developmental activities provide the behavioural foundations for fulfilling strategic intent in the long run. For better understanding, we make a direct comparison here.

In general, Group-A firms concentrated on the localisation of production, and followed the arrangements recommended by the foreign sides. Their efforts brought about the growth of operational skills but the neglect of systemic product development because of a series of limitations and inducements. Such a trend had solidified along with their development in the last three decades. Group-B firms on the contrary had insisted on in-house product development, which certainly had not evolved smoothly. However, they had all the time kept the dominance of their product development process.

5.4.1 Developmental activities

(1) Activities at the centre of learning

Taking the car-making sector as an example, a comparison of major activities of Group-A and Group-B firms is demonstrated by Figure 5.6.

Figure 5.6 Activities carried out by Group-A and B firms (car-making sector)

[Insert Appendix-3 here]

The mainstream activities of Group-A firms were the localisation of production. Besides the routinised manufacturing practices, they also implemented a series of complementary functional activities, such as for market research and feasibility analysis; but these activities were organised not for uncertain and developmental ends, but just for adopting existing products of foreign partners. During their production localisation, they also had to develop relevant methods and equipment for mass production. But most product development procedures which logically should be located between market research and production, i.e. the product model development, the prototype development and the engineering development for mass production, were absent in Group-A firms. The outcomes that ought to be developed through these procedures were brought in with codified blueprints and data in theory. Therefore, according to the activities carried out by Group-A firms, learning happened as mainly centred production lines.

In comparison, Group-B firms might not be able to produce some high-tech and high-precision subsystems in their early phases. However, they did not miss any generic critical procedure of product development. Even for those outsourced subsystems or components, Group-B firms also gradually built up corresponding in-house development platforms. Moreover, "*inspecting and confirming*" sections for all development procedures were implemented in-house, or by delegated teams. Certainly, Group-B firms also carried out other activities, such as market research, feasibility analysis, production line development and manufacturing practices.

In Group-A firms, the activities at the centre of organisational learning also included periodical localisation of imported product models. The purpose of model localisation could be to meet local regulations, to utilise local supply networks better, or to satisfy local demands better. However, whatever the purpose was, these projects entailed only partial designs of corresponding product systems. Group-A firms only had the IPRs of adjusted parts, not the whole product systems. Even for the adjusted parts, the Chinese in most cases did not have the *inspecting and confirming rights* for most (if not all) sections and steps of development. These rights were attributed to the foreign sides. As *inspecting and confirming* were methods for both technical control and governance control, without approval, technical changes were not allowed to be put into effect, and relevant resources were not allowed to be allocated for generating these changes. Therefore, the Chinese sides did not have practical control of development processes, including any decision-making about what to learn, when to learn, how to learn, or even who could learn through these projects. In fact, since the foreign sides would not allocate many excellent personnel permanently to Sino-foreign JVs, these localised adjustment projects were usually led by visiting (or temporarily hired) engineers sent by the foreign sides[94]. This not only cost financial resources in Sino-foreign JVs, but importantly had these tasks planned and technically dominated by "outsiders". In other

[94] It explains why we find special items in the payroll books of Group-A firms. For example, during the localisation of production for *Jetta* in the early 1990s, FAW-Volkswagen employed a group of visiting Volkswagen technical experts, who belonged to Volkswagen, not to FAW-Volkswagen. Even with the rotation of visiting experts, the total number was still around 60 at any specific moment of this period. For each visiting expert, the expenditures were 3.6 million RMB per year exhibited in the payroll books. JinBei-GM, the cost of every visiting expert was 0.36 million USD/year.

words, the outside engineers representing external benefits and external knowledge creation systems played the integrative roles in the learning processes of Group-A firms through these projects. Important parts of relevant experience would not be retained by domestic organisations, since outsiders were not stable elements of them, and the developmental activities of visiting engineers did not originate from local Chinese learning systems.

(2) Marginalised activities

Group-A firms also had implemented several (but only several) new product development projects in the past two decades. Certainly, it could be argued that these marginalised projects might work as experiments and seeds for in-house capability building, but this arises only in theory. In the past twenty years, the seeds have not been transplanted into the centre of Group-A firms' technological learning. These projects were never connected to the mainstream technological learning practices and resource allocation, or formally to the major SECI processes of knowledge creation in Group-A firms.

Basic technical exploration had also implemented by some Group-A firms. These activities were mostly isolated from the practical major activities (production localisation) and practical product development, since the R&D centres were not authorised with resources to carry out practical product development.

By comparison, the development of products was carried out as the centre of developmental activities in Group-B firms. They also implement long-term technical exploration. The departments of long-term technical exploration were spin-offs from the product development work forces; and at least to date they have had substantive schedules to industrialise their findings into engineering applications. Such a tight connection was inherited from their product-oriented competitive strategy.

5.4.2 Strategic intent

There is no common quantitative measure for strategic intent. However, we can identify the difference by their attitudes and long-run activities, and such a comparison shows distinct different between these two groups of firms.

In general, both groups of firms shared similar strategic intent at their start-up phase. The original intention of TMFT policy was to facilitate both indigenous technological capability building and import substitution, while that of Group-B firms was for indigenous technological capability building and business survival.

Nevertheless, during TMFT practice, Group-A firms had gradually marginalised their intent of product development. A business model based on stretching production capacity, benefiting from governmental support and *de facto* market advantages, underpinned the shift. Their strong reliance on current profitability deflected them from the wider development of capabilities (Kogut and Zander, 1992, p393). There were controversies within the Group-A firms; however, in-house appeals for indigenous systemic product development rose and fell sporadically. Although what the decision-makers did in those circumstances might not mean giving up the previous developmental intent in the long run, these results did change their organisational cultures, and their mainstream views on technological learning within organisations. Even with their growing financial strength, chances for their revival of in-house systemic product development were seldom retained. Some engineers thereby left Group-A firms and joined Group-B firms in order to pursue indigenous capability building.

In comparison, the strategic intent of Group-B firms was enhanced by their continual practice of developing complex technologies, components, subsystems and systemic products. Sharply distinguished from the strategic choices of Group-A firms, Group-B firms rejected proposals from MNCs to set up JVs under the TMFT framework when they had already proven their potential.

The contradistinction about the strategic intent of these two groups of firms was highlighted in a public controversy during 2004-2005[95]. Major Group-A firms expressly opposed stressing indigenous product development, and listed a series of "*reasons*" to validate their rationality, most of which were termed preconditions for in-house technological capability building and were related to resources or production capacities. Even when those preconditions had been fulfilled[96], they simply piled on the thresholds again.

The more substantial vote by Group-A firms was their continual renewal of productive JV contracts with MNCs. Take the SAIC as example: its previous JV contract with Volkswagen covered 25 years, 1985-2010 (practical cooperation started in 1984). In 2002, when there were still 7 years to go, SAIC decided to extend this contract for 20 more years. In the new contract, there was no clause stressing systemic products development carried out indigenously or cooperatively. Even the previous clauses regarding the rate of manufacturing localisation were eliminated as "old-fashioned". All contents were set for continuing import of product models and for stretching production capacity.

SAIC was no exception among Group-A firms. Rather, it was typical for Group-A firms to do so or to continue setting up new JVs with new foreign partners for manufacturing localisation. The latest dates of the current JV contracts for FAW, DongFeng, SAIC, Beijing Auto and Guangzhou Auto are now 2041, 2053, 2030, 2035 and 2034 respectively. Table 5.12 highlights this common

[95] In fact, this public controversy was raised firstly in the car-making sector and gradually spread to broader manufacturing industries from 2000. The report of *NanFeng Chuang* Journal (No.4, 2000), named "*ZhongGuo QiCheYe de ShengSiJie (Life or Death for China's Auto Industry)*", was recognised as an earliest editorial for this topic.

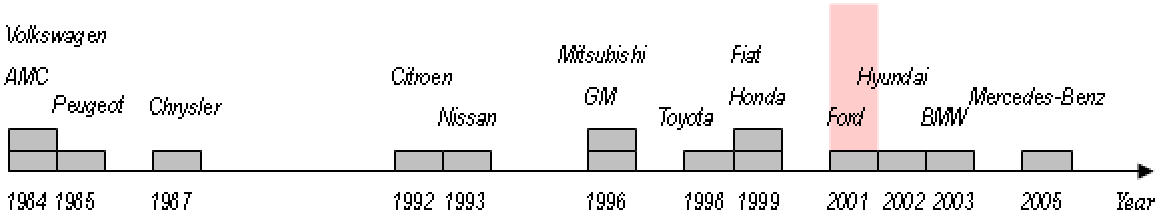
[96] The actual output of SAIC-Volkswagen had exceeded 0.3 million sets by 2002, and the total output was 0.49 million sets for SAIC as a whole in 2002, and 0.6 million in 2003. FAW had also output of over 0.5 million sets in 2003.

feature. Figure 5.6 reflects another fact, that most giant car-making MNCs had been gradually introduced by Group-A firms as JV collaborators under the TMFT framework.

Table 5. 12 Continuous establishment of JV by Group-A firms

[Insert Appendix-4 here]

Figure 5.7 Entry time of MNCs under the TMFT framework (Passenger cars only)



Note: The date is only for the start of production localisation by Sino-foreign JVs in manufacturing completed products of passenger cars, not the date for JVs being established or for other kinds of JVs.

In the public controversy, Group-B firms were criticised by some media that might have the encouragements from Group-A firms. By the criticisms, manufacturing quality, production capacity (at that moment), and non-frontier technical features of products in comparison with those of Group-A firms or imports were usually stressed. However, no Group-B firms changed their strategies confronting these criticisms. Rather, they fought back in public and announced new investment plans, which received support from some ministries, such as the Ministry of Science and Technology, the China Development Bank and the Export-Import Bank of China.

In 2005, the Chinese central government announced a change of national strategy that indigenous innovation capabilities and the "*quality of growth*" ought to be highlighted instead of pure GDP advocacy and the growth of manufacturing capacity based on low-cost labour. This change was manifested with the "*National Guidelines on Medium and Long-Term Programs for S&T Development (2006-2020)*" in 2006. Only after that did Group-A firms have to announce a series of plans in the name of "indigenous product model development" to respond to the pressure imposed by the government and the public opinion.

Therefore, we can conclude that during the past two decades of TMFT practices, Group-A firms gradually deviated from their original strategic intent. They stressed the expansion of production capacity and marginalised the importance of in-house product platform building. Comparatively, Group-B firms insisted their strategic intent from their beginnings.

5.4.3 Technological progress

Before 2005, there was no systemic product or complex product technology that was developed and industrialised by Group-A firms[97]. On the contrary, Group-B firms had continued launching new products, and launching complex technologies presented by these products.

In the telecom-equipment sector, Shanghai-Bell, which had been a manufacturing base for the global development strategy of Alcatel since 2001, was able to provide its domestic users with customised network solutions, which represented the most advanced capability in-built among Group-A firms in this sector. However, the major products adopted in Shanghai-Bell's solutions were based on imported models, except for several modules mentioned previously that they developed locally. Since the Chinese side had totally lost the dominant roles within Group-A telecom-equipment firms, there was seldom significant improvement after the policy change in 2005.

In the car-making sector, from 2005 Group-A firms launched a series of "indigenous product development" projects as responses to the change of government policy and social opinions (see Table 5.13). Nevertheless, their projects continued to rely on foreign partners. In fact, Group-A firms had not yet raised a full set of developmental activities in-house. Then it remained difficult for them to generate in-house technological capability as they claimed.

Table 5.13 New "Indigenous" Products of Group-A firms (from 2004)

[Insert Appendix-2 here]

Among these new product models, some were entirely outsourced. For example, the *Besturn* of FAW was a model that had already been completed by Italdesign in the mid 1990s; some were based on imported platforms. For example, the *RedFlag-HQ3* of FAW was based on the 2000 annual version of *Grown-Majesta* (Toyota). Moreover, SAIC acquired two experienced product development teams from overseas. However, front-line engineers of SAIC in China were barely involved in the relevant development activities of these overseas subsidiaries.

By contrast, Group-B firms displayed good performances in new product development. In the past 10 years (1998-2008), not including earlier periods, the number of new product platforms launched by Chery, Geely and HaFei was 10, 8 and 4 respectively. The progress of Group-B firms

[97] Regarding this point, this might be controversial for the case of Tianjin Auto among some Chinese scholars. Tianjin Auto got its *XiaLi* minicar model in 1984 as a localised version of the *Charade* model, by a productive cooperation project with Daihatsu (Japan). Dissimilar to most model importing projects, Tianjin had the IPRs of the *XiaLi* model, and produced it by CKD imports before 2000. Because of the self-owned IPRs of this model, Tianjin Auto made several improvement versions of *XiaLi*. However, no significant change was made before 2000 since the production did still rely on imported CKD critical subsystems. And the platform (based on the original model) was backward, being developed by Daihatsu in the 1970s, so that it allowed very limited space for the Chinese to implement incremental improvements unless local engineers were encouraged to make significant technological changes upon this platform – but these did not happen. On the other hand, although the platform of *Charade* was promoted several times by Japanese, upgraded technologies had not been transferred to *XiaLi*. Only after Tianjin set up productive a JV with Toyota in 2000, obvious changes were made through importing and localising the production of the later version of *Charade* (Toyota acquired Daihatsu in 1998). But the *Charade* had stopped production in Japan since 1999 for its backwardness. Thus, we do not support the view that Tianjin Auto had established obvious technological capabilities.

had changed the domestic market structure, and upheld a lasting product-oriented competition that had never happened in China before. Before 2001 even though many MNCs had established productive JVs in China, the number of car models launched in the Chinese market was truly small. The "*Old Three*" had a market share of over 50% during most of the 1990s. In 2000, only 12 models in the Chinese market achieved production volumes over 10,000 sets in that year. In other words, most domestic customers could choose from just these 12 models. In 2001, there were only 13 models newly launched in the Chinese market. Ironically, there had been 12 giant MNCs that had set up productive JVs in China by 2001. The emergence of Group-B firms pushed the competition in the Chinese market becoming product-oriented. MNCs had to launch more and more, and better and better models in China as responses. The number of newly launched models increased from 80 to 120 after 2005, and stayed at a comparatively high level since then (see Table 5.14).

Table 5.14 Car models newly launched in the Chinese market

Years	2001	2002	2003	2004	2005	2006	2007	2008	2009
car models newly launched	13	28	50	50-	80+	117	90	107	221

Source: from varied sources;
Note: the statistics include common cars (sedan, hatchback and station-wagon), MPVs and SUVs.

The market share of previously leading car models clearly fell. The "*Old Three*" models still occupied 47% of the domestic market in 2001, but their share fell to 34% in 2002, and to 18% in 2004. Their absolute sales went down with a lost of 43%, 70% and 77% respectively in 2004. The average price per set of these three models was about 140,000 RMB in 2002, while only around 60,000 RMB in 2008.

Moreover, this tough product-oriented competition and the progress of Group-B firms had promoted the technical levels embodied in car models in the Chinese market. Considering the market segment of family-use cars, namely A-level cars, we can find significant changes by studying the technical modules employed by these models. In addition to the "*Old Three*", Chinese media generally select three A-level cars as the "*Medium Three*" and three as the "*New Three*", which were all produced by Sino-foreign JVs; their emergence timing and popularity on Chinese market are the criteria for selection. These selected models represent the general technical levels of imported models at corresponding time periods, as shown in Table 5.15.

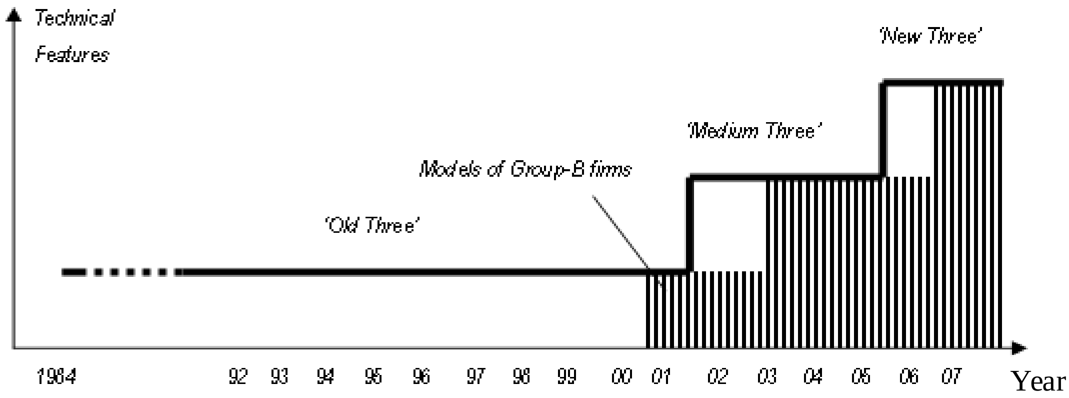
Table 5.15 Popular A-level cars in Chinese market and their technical features

Jargons	Car models (their former names in MNCs)	Launch-time in the Chinese Market
"Old Three"	*Santana* (Passat-B2, Volkswagen) *Jetta* (Jetta-A2, Volkswagen) *FuKang* (Citroën-ZX,Citroën)	1984-1992
Technical Features*	Styling: square-based shape, wedge-shape Security: no ABS, no airbag, etc. Driving Comfort: no power windows, no power-assisted steering, etc. Chassis System: solid axle suspension Warranty: 2 years or 40,000 km	
"Medium Three"	*Elantra* (Elantra-6, Hyundai), *Familia* (Mazda-323, Mazda), *Excelle* (Nubira, GM-Daewoo)	Around 2002
Technical Features	Styling: curve-based shape, streamlining Security: ABS, EBS, 2 airbags; Driving Comfort: power-assisted steering, PDC, power windows, air-conditioning with main console, CD player, etc. Chassis System: independent suspension Warranty: No general standard	
"New Three"	*Focus* (Focus, Ford-Europe), *Sagitar* (Jetta-A5, Volkswagen), *Peugeot307* (Peugeot307, Peugeot)	Around 2006-2007
Technical Features	Styling: wide-bodied shape**, semi-coupe style Security: ABS, EBD, ESP, 4-6 airbags; Driving Comfort: CAN-bus, EPS, multifunction steering wheel, power-assisted steering, PDC, power window lift, air-conditioning with main console, intelligent voice guide system, DVD and MP3 player, Bluetooth application, etc. Chassis System: independent suspension with rear multi-link Warranty: 3 years or 100,000 km	

*Note: * this is for the early versions of these car models in question; **wide-bodied designs are usually 1750mm in width, while the former designs of A-level cars were usually 1700.*
Terms: CAN: Controller Area Network; CD: Compact Disc; EBD: Electric Brake force Distribution; ESP: Electronic Stability Program; MP3: MPEG Audio Layer III; PDC: Parking Distance Control.

Even though MNCs continually launched better models by local production, Group-B firms succeeded in keeping pace to catch up. In 2001, when they were officially allowed to enter the car-making sector, the first-generation car models of Chery and Geely were only approximately equivalent to the "*Old Three*" if ignoring their backwardness in manufacturing precision. Only the *Lubo* model of HaFei already embodied major technical features of "*Medium Three*". Around 2003, when Chery and Geely launched their second-generation products and the upgraded versions of their first-generation models, could they provide most technical modules adopted by the "*Medium Three*". In 2005, HaFei launched its *SaiBao-3* model, and Chery and Geely launched their "global cars" (third-generation) around 2006-2007, which meant these models were designed for the global mainstream market. These models had technical features similar to those of the "*New Three*", and their manufacturing qualities became comparable to those of mainstream Group-A products. Hereby, we draw a schema regarding the catching-up of Group-B firms in reference to providing advanced car models as Figure 5.8.

Figure 5.8 Group-B firms chasing after products of MNCs (schema, car-making sector)



In the telecom-equipment sector, Huawei and ZTE had developed beyond the "product following strategy" implemented in previous phases, and became innovators in a global sense. The case below can present exactly such a shift.

TextBox 5.4 Huawei's leading capability in developing soft-switch technology

Since 2003, Huawei began to win big deals through tough competition against international giants in global mainstream market for its WCDMA R4 equipment, for which Huawei's strength in soft-switch technology and in relevant derived solutions were critical.

Before the real industrialisation of R4, the WCDMA (3G) network construction was dominated by the R99 version based on circuit-switch technology. The emergence of R99 was disruptive for the former 2G network (GSM) since it required the replacement of most existing equipment. By contrast, the development of R4 version, which was led by Huawei and only a few international competitors, could provide smooth evolution from the 2G system to 3G, because its embedded soft-switch technology promoted the compatibility of operation, reduced relevant hardware replacements and finally realised the near universality of the core-network layer between the GSM and the WCDMA systems.

In the industrial community of WCDMA, Huawei was a latecomer outside the original constitution for the R99, R4, R5 or R6 versions of WCDMA in terms of the theoretical scheme[98]. However, its success in soft-switch technology and its R4 development exhibited systemic understanding held by its in-house engineers about the product and technical system of both 2G and 3G networks, since the original scheme of these standards did not indicate practical threads

[98] The soft-switch technology and R4 version of WCDMA were not invented by Huawei. The R4 was schemed by the WCDMA industrial alliance as one-step of the evolution of WCDMA, and passed by ETSI (European Telecommunications Standards Institute) with soft-switch as an element included. However, technical standards only provided ideas and basic parameters. They could be realised only with the efforts of equipment providers in developing product systems and networking solutions.

for industrialised designs, especially for those creating smooth evolution for the installed equipment of the last generation. Otherwise, without substantial understanding, they would have followed the R99 version as other major global competitors did, since with a product follower strategy latecomer firms would study existing models on the market and develop their product systems by following the existing framework.

Hereby, Huawei's global leadership in soft-switch technology reflected not only its progress in particular technologies but also, by its performance in reconstructing the mobile telecom systems, its accumulation of systemic understanding. Only with that, could Huawei invent a new technical trajectory, and develop the R4 into a competence-enhancing innovation for its customers rather than a competence-destroying solution, which was indeed disruptive for equipment providers concentrating on R99. Therefore, we can say Huawei was no longer a strategy follower.

Certainly, we should not neglect the resources investment of Huawei: to realise this progress, Huawei invested at least 1 billion RMB each year during 1998-2004 for R&D in this field.

In short, there were distinct differences between these two groups of domestic firms regarding the developmental activities. As the developmental activities in a long run could be regarded as the weathercock of strategic intent, the differences reflected that Group-A firms had deviated from their original intent of in-house technological capability building. The growing experience earned through TMFT practices had not brought forth any signs about strategic shift of Group-A firms until recently. By comparison, Group-B firms insisted on their original intent. Certainly, we cannot attribute the performance differences in capability-building as a whole to the difference of strategic intent. In the next chapter, we explore the organisational learning systems of these firms, which should be regarded as the organisational translation of strategic intent in the long run, and as the organisational platforms for the learning activities.

Chapter 6. Comparison: authority, organisational integration and knowledge accumulation

6.1 Introduction

In this chapter, we present the comparison of the authority over strategic resource allocation, the arrangements for organisational mobilisation and learning integration, and the facilities and institutions for knowledge accumulation between these two groups of firms.

This empirical study will argue that the organisational learning systems established by Group-A firms were highly specialised but rigid. Resource allocation was dominated by top managers with backgrounds in production, marketing or finance rather than in the development of products or relevant complex technologies. The production localisation practices were divided into specialised domains and carried out by different organisational units. The scope for communication and knowledge conversion of the front-line engineers was confined within their specialised units. Correspondingly, the knowledge databases, if ever established, were unilaterally manipulated by knowledge gatekeepers of specialised units. The knowledge database was formed as the summary of experience collected every few years, or even as translated versions of manuals of their foreign partners.

The learning activities of Group-B firms were organised differently. Top managers from product development divisions had more influence on allocating strategic resources. Even though a specialised structure of departments was also employed, institutions were set up to ensure the developmental activities were carried out on cross-boundary, inter-departmental organisational platforms. Substantial communications across specialised departments were guaranteed for engineers to facilitate their knowledge conversion. The knowledge database was set up as tightly coupled with the dynamic developmental activities; meanwhile it was also accessible to organisational members across a broad scope. In fact, in many cases, the knowledge database worked as the platform for the inter-departmental collaboration and learning in real time.

6.2 Organisational learning systems of Group-A firms

6.2.1 Authority over the allocation of strategic resources

We take the formation of the top committee[99] for strategy making of firms as the agent to be

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[99] The top committee, in this thesis, refers to the committee in charge of strategy making. The top committees vary in form from the directorate board to the executive management team (EMT) in different firms, and there may be overlaps of personnel between them. In most Group-A firms, it is the directorate board acting this role, especially noting that only at this level that Chinese sides can negotiate with foreign sides effectively. In Group-B firms, directorate boards are usually away from practical strategy making, but focus on maintaining and increasing the asset values. Certainly, the specific names of these agents would differ in different cases.

analysed for our study of their authority over the allocation of strategic resources. We cannot assert that such an agent accurately presents the distribution of decision-making power within these firms, but it at least exhibits the comparative importance of different divisions by reference to the allocation of strategic resources.

In Group-A firms, the engineers who were expert in product and product technology development had little impact on the top committees. This can be explained by the following reasons:

Firstly, the tradition of the central planning system mattered. The former governmental branch-based industrial administration, which was set up for static professionalization, had these backbone SOEs to focus on production and stay away from R&D to some extent. In backbone SOEs, there were only "product office(s)" to handle incremental improvement tasks and the technical documents. Most SOEs relied on industrial research institutes for new product design and complex technological development. Alternatively, important product technologies were developed by government-led projects at the industry level. Therefore, when Group-A firms were transformed from SOEs, they carried on the production-oriented tradition for decision-making.

Secondly, the legacy learned from the Soviets had also led to the inferiority of R&D in their power distribution. As noted, the modern Chinese industrialisation was largely influenced by the Soviet form when it began, which brought in some features of Soviet factories. To take the automobile industry as example, at that time, the automobile product models of Soviet Russia were largely transferred from other countries, such as the USA and Czechoslovakia. Therefore, the significance of in-house R&D was underestimated and the executing agencies were limited as only sub-department "product office(s)". The situations of most Chinese SOEs were the same.

Thirdly, in the early phases of Sino-foreign JVs, the Chinese R&D personnel had obvious disadvantages in terms of technological capabilities compared to foreign experts. This fact resided not only in the comparatively backward status of the domestic community, but also in the legacy of central planning. The branch-based industrial administration had the SOEs and research institutes as executors of professional tasks only when the ministries worked as the headquarters for strategy-making of industries, which left the front-line economic units short of experience related to technological integration. When the open-door policy was implemented, local engineers found themselves deficient in handling the imported products and subsystems, which were complex and stressed integrations of multi-disciplinary technologies. This led to marginalisation of their roles within the organisations while the leading roles were attributed to the foreign sides.

Fourthly, the practical business model focusing on the expansion of production localisation did not favour a workforce for in-house product development. The incomes of Group-A firms depended mainly on the localised production of imported models, while the in-house development of systemic products and complex technologies acted only as cost bearing rather than profit making. So when the Group-A firms lacked confidence in the efficiency of their learning to catch up in technological capability, and perceived financial tensions in their early phases as dangerous, the in-house development of product and relevant complex product technology was regarded as risky and uneconomic, and thus not appreciated. In fact, in Group-A firms, the R&D teams and product developers were usually interrupted from their own schedules, and directed to the tasks of production localisation. Sometimes, such assignments were even permanent in the interests of organisational reform or modernisation[100], which caused a somewhat irreversible weakening of the in-house labour forces for product development.

Last but not least, from the accumulation of the above factors, the lack of indigenous product developmental activities led to a decline of real product developers in absolute amounts. For example, the number of engineers in FAW who had the abilities and could be mobilised to take part in configuring new car model development did not exceed 10 in 2006[101]. As the in-house development of product and relevant complex technology was marginalised, it was difficult for developers to attract younger generations to replenish the workforce.

Therefore, in Group-A firms (see Table 6.1), the engineers from production lines held more power on top committees, as well as personnel from marketing and finance. As a legacy of the central planning era, the administrative cadre also had their voice on top committees. The R&D engineers usually had one but only one seat to represent the department-level R&D centre.

Table 6.1 Structure of Top Committees of some Group-A firms (2007)

Managing and Decision-making Committee	FAW	DongFeng	SAIC
Total number of members	10	10	16
-Members with technical or engineering background	5	6	5
--Members with product development experience in car-making sector	3	0	0
---Members with corresponding experience in the past two decades	0	0	0

Note: for the SAIC case, we calculate the data for the directorate boards and for the EMTs of the SAIC Group and of the SAIC Motor together. The SAIC Group had an 83.83% share of SAIC Motor.

Take the FAW case in the table. On FAW's top committee in 2007, there were 5 of 10 who had not had engineering or technical backgrounds but were experts in other domains, such as administration, finance or human resources. Among the 5 with engineering and technical backgrounds, 2 were from the production lines. Another 2 out of the other 3 had technical development experience, but they gained this before the 1970s, before they were switched to management roles in workshops or factories. Only 1 of the 10 on FAW's top committee represented the R&D centre. However, except for basic research and design localisation of

[100] An extreme case happened in the power equipment sector when XiYi, the largest power instrument provider in China, was encouraged to establish a JV with Yokogawa (Japan). In this JV, in the name of organisational reform, 200 product developers and scientists from XiYi's national-level R&D centre were allocated to the marketing and post-sales service departments. Only about ten scientists were left in a nominal R&D centre to carry out the model localisation tasks.
[101] From the interview with Zheng Cheng (2007), the chief configuration designer of *RedFlag* during 1958-1995.

imported models, the R&D centre had never officially carried out new product development in the car-making segment after 1994 (the centre was in charge of product development for trucks, but the truck division was not involved in the TMFT framework).

6.2.2 Patterns of organising learning: a professional and rigid system

With a primary stress on production localisation, the organisational systems of Group-A firms were built to be highly specialised but also rigid, which led to the fragmentary formulation of knowledge generation and accumulation.

The localisation of production in Group-A firms was first divided into specialised tasks, and carried out by specialised affiliated or correlative firms and factories individually. As the imported product models had already been well developed, there were few uncertainties regarding job-allocation and technological integration among subsystems and components. Only when local participants could not reproduce some designs accurately enough or some subsystems had not been imported would in-depth interaction and cooperation among relevant local participants and foreign sides be implemented.

Further, within every local organisation involved in such a process, a similar mechanism was implemented to study the imported designs. The learning requirements were divided into specialised segments. The chiefs of each segment played the leading roles, or in other words, they were the gatekeepers of technological learning. This brought fundamental difficulties to bear for mobilising organisational members and for integrating learning activities.

6.2.2.1 Learning among firms based on production localisation

The production localisation of imported models was divided into specialised tasks among a series of affiliated or correlative firms and factories, namely the integrators, associated suppliers, affiliated subsidiaries and in-house factories. For example, for Shanghai-Volkswagen, over 400 domestic firms were involved in cooperating with Volkswagen and global suppliers appointed by Volkswagen to establish the local manufacturing and supply system. As for Shanghai-GM, the number of new foreign-local cooperations was some 300 since Shanghai-GM was able to make use of some localised suppliers of Shanghai-Volkswagen.

In reference to each task that corresponded to particular subsystems or components, the designs had been well developed and frozen by their original foreign developers. Thus after the tasks had been assigned, learning was carried out separately by associated firms and subsidiaries, not tightly coordinated by the productive JV or the corresponding Group-A firm in terms of detailed learning activities. Therefore production localisation was carried out without any organisation becoming responsible for real technological integration. In such a system, the organisations which were named as “integrative” or “general” were not really responsible for integrating the learning activities among participant organisations. For instance, the "*general leading office*" that was established during the construction of the local manufacturing and supply network was only responsible for the layout of tasks, the generation of schedules and administration relevant to the time and resource dimensions. The general assembly factory, as integrator in terms of the physical shape of products, was just to accomplish the final manufacturing and assembly. In product development sequences there was no concrete learning activity at the systemic product level among participant organisations.

From this, it can be claimed that production localisation was constructed out of segmentally specialised manufacturing services provided by participant organisations. The technical interactions among these service providers were framed by well-designed interfaces within the product system. The contents of communications among them, certainly, were based on the dimensions of these interfaces, such as the sizes and positions of components and the power takeoff of the engine. The communications were carried out at firm/factory level only, by representative personnel who might not be engineers. It was impossible for front-line engineers in one participant organisation to mobilise resources, information and personnel from another cooperating organisation in real time for the needs of development and learning.

Table 6.2 Local participants for the production localisation of *Santana* (examples, incomplete)

ıies	Tasks
ai Automotive Gear Works.	Gear box manufacturing
ai GKN Drive Shaft Co.	Drive shaft manufacturing
ai Huizhong Auto Manufacturing Co.	Chassis assemblies, e.g. front suspension, sub-frame, rear axle, control arm and shock absorber
ai Sanden Behr Auto Air Conditioning Co.	Air conditioning system manufacturing
ai SIIC Transportation Electric Co.	Auto motors, auto electric and electronic appliances
pring Factory	Automotive suspension springs, engine valve springs, stabilizer bars, die springs, shaped springs, etc.
; Visteon Auto Trim Systems Co.	Trims, including electronics subsystems (multimedia, cluster, HVAC controls), seat subsystems, overhead subsystems (door panels, instrument panels, console, pillar trims, soft trim), exterior subsystems (fascia, cladding, grille) and safety subsystems (steering wheel, airbags, seat belts)
ai Koito Auto Lamp Co.	Lamps manufacturing
;chmidt Shanghai Piston Co.	Piston manufacturing
ai Auto Clutch Works.	Clutch manufacturing
ai Delphi Auto Air Conditioning Systems Co.	Air conditioner manufacturing
ai Ri Yong - JEA Gate Electric Co.	Radiator fan assembly manufacturing
ai Powder and Metallurgy Plant	Producing iron-based powder metallurgy parts
rs]	…

Table 6.2 lists a few of the 400 participant organisations involved in the production localisation of the *Santana* model. The segment-based specialised system was coordinated with governmental support, similar to the "1240 Bureau" which was supported by the government to coordinate the production localisation of the *S1240* PDSS produced by Shanghai-Bell. An alliance named

"*Shanghai Santana Localization Community*" was formed in 1988, headed by SAIC and Volkswagen, with 105 founding suppliers, 16 research institutes and banks. This did not mean that before 1998 SAIC did all the developmental tasks in-house. Rather, before 1988, SAIC only did the assembly based on CKD imports, except for a short list of localised peripheral components such as the tyres, radio, horn, antenna, and nameplate.

In order to provide qualified manufacturing services, most participant organisations were required to establish JVs or technical cooperation with foreign partners in the original value network of Volkswagen. Similar patterns of learning to the Group-A firms were also implemented for integrated products. Again, we do not mean to deny the progress that domestic suppliers had obtained through carrying out TMFT practices in terms of precision processing and managerial skills. However, these local participants also had to tie them to foreign partners, and many of them had no independent strategy and implementation of product or critical technology development. For example, the Shanghai Clutch Factory had already been well-known in the domestic community for its product development capability. Even in the central planning era, it could actively develop customised clutches for many users. Nevertheless, in order to suit itself to the production localisation led by Shanghai-GM, it was encouraged to transfer itself into a JV with ZF Sachs AG, as introduced by GM in 2002. In spite of the promotion of processing technologies, its product development team had been cut off. Thereby, when its previous domestic customers contacted it for new product development, Shanghai-Sachs, the JV, had already lost the capability that Shanghai Clutch Factory previously had, and could provide only products mainly based on the existing designs of Sachs.

As for the Group-A telecom-equipment firms, the situations there were similar. For example, the LSI chip production of *S1240* was localised by BeiLing, a productive Sino-foreign JV, which was built according to the original Shanghai-Bell contract. However, the construction and development of BeiLing had little to do with the learning practices of Chinese engineers in Shanghai-Bell. Certainly, from another perspective, Shanghai-BeiLing did have little technical information to communicate in practice other than its processing dimensions. What it did in the localisation was just to set up the manufacturing base. The major equipment that it used had been well developed or appointed by the foreign side, and the products it processed had been well-encapsulated by the Belgium BTM. Without touching the substantial technological contents of the objects, namely the designs of ICs, and without integrative thinking about the relevant interfaces, Shanghai-BeiLing really had very little to communicate to Shanghai-Bell in terms of micro-level knowledge creation, and *vice versa*.

6.2.2.2 Learning within firms based on production localisation

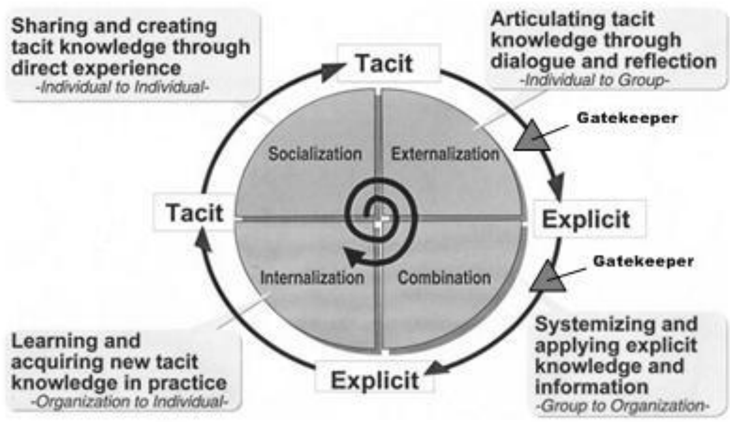
Within each participant organisation, the division of labour for production localisation also entailed institutionalised barriers for front-line practitioners to generate understanding of the product systems. Being directed to imitate the imported models as accurately as possible, the tasks of localisation they carried out were also divided into specialised segments. The chief experts and administrators worked as leaders for the learning activities within each specialised segment, whom we refer to as the "gatekeepers" of knowledge creation within corresponding organisational units. In the flux stages of production localisation, these leading roles were fulfilled by foreign experts who were temporarily sent in by the foreign side.

In fact, the knowledge-gatekeeper institution is broadly adopted in firms, including Group-B firms. Some scholars, such as Allen and Cohen (1969) and Tushman (1977), stress the importance of "*gate-keeping*" and "*boundary-spanning*" in organisations. Cohen and Levinthal (1990) argue that the absorptive capacities of firms depend on the individuals who stand either at the interfaces between the firm and the external environment or at the interfaces between subunits within the firm. Particularly for technical information that is difficult for internal staff to assimilate, the gatekeepers both monitor the environment and translate the technical information into forms understandable to the internal group (ibid, p132).

During the development of Group-A firms, the chief experts of specialised segments did work actively on translating technical information about production localisation into understandable language for affiliated members. Within their organisational units, they worked as leaders for the decomposition, assignment and coordination of tasks, and to ensure the efficiency of specialisation. However, their role of monitoring the outcomes of organisational learning which converged on existing imported designs should be especially underlined. Since to imitate imported models as accurately as possible was regarded as critical for production localisation, and as economical for technological learning, the gatekeepers stressed realising the imported well-designed details rather than exploring any heterogeneous ideas. Heterogeneous ideas were regarded as bringing about design changes and additional "unnecessary" uncertainty, which implied unstable, unexpected and additional time- and resource-consuming outcomes, and then were not appreciated by the business models and learning patterns of Group-A firms.

Therefore, from the perspective of knowledge creation, the gatekeepers handled the information that arose within their organisational range by working as learning organisers and information filters to select and record particular knowledge flows. The intellectual outcomes that were taken as irrelevant to the organisational goal of imitating the existing imported model, no matter whether it was tacit or codified, would not be recorded as organisational memory and would not be transferred through the gatekeepers to the upper level of the organisation. If we apply this point to the SECI knowledge spiral (Nonaka and Takeuchi, 1995; Nonaka and Toyama, 2002), the chief experts here worked as the split-flow valve of technical information flow (see Figure 6.1).

Figure 6.1 Information gatekeepers of the SECI process



Note: the original figure of the SECI process is from Nonaka and Toyama (2002, p996)

Such a gatekeeper arrangement depressed the amount of heterogeneous thinking and discussion carried out by subordinate engineers. Besides, the in-depth cross-boundary platforms of communication and learning interaction among front-line engineers from different segments were inactive, since these would be opposed to control by gatekeepers.

However, a diverse knowledge structure within an organisation was critical to elicit learning and problem-solving leading to innovation (Simon, 1985). The gatekeepers of Group-A firms worked beyond directing and translating external information for in-house learning, but restricted the range of knowledge search and conversion. Under such a system, they aimed at avoiding the trial-and-error process of learning as waste. Learning and knowledge accumulation was directed to follow the imported designs that were finite in amount. Particularly since the interfaces within imported products had been well developed by the foreign sides and local learning tasks were divided by these interfaces, the lack of effective cross-boundary organisational platforms undermined learners' understanding about the interfaces, relevant design logics and system integration. Therefore, what had been built through the learning practices based on production localisation in Group-A firms was a highly fragmentary knowledge creation system regarding the product systems and product-relevant technologies.

6.2.2.3 Learning based on in-house R&D

As already observed, there were still R&D personnel, R&D departments and R&D activities in Group-A firms. The in-house R&D forces of Group-A firms could be legacies accumulated before the TMFT era[102], or were developed in response to governmental encouragement or requirements, or were invested in according to a "*production plus R&D*" strategy. Regarding the last source, decision-makers of Group-A firms thought by financing in-house R&D activities they could promote technological capability building naturally only if these activities were really R&D-relevant and carried out in-house. Such thinking could be understood as the "absorptive capacity" model in a narrow sense. However, significant barriers resulting from the organisational learning systems and underlying institutions impeded the effectiveness of this strategy.

As discussed in Chapter 5, the marginalised role of the in-house R&D workforces in product development could not simply be attributed to the lack of R&D investment. Even with concerns of financial tension, the financial situations of Group-A firms in their early phases were still much better than those of Group-B firms. In terms of R&D personnel, as backbone SOEs, Group-A firms also had occupied most elites of the former central planning industrial system (see the last footnote for the case of FAW). Indeed, because of the original intent of indigenous technological capability building formulated by the TMFT policy, there were generally special clauses in JV contracts to stipulate the ratio of revenue for R&D expenditure. Relevant overseas programmes for training R&D personnel were also scheduled. In Shanghai-Bell, the R&D foundation was cited in the contract as 3% of annual sales[103]. In Shanghai-Volkswagen, 3% of the sale value was obligated to building a technical centre. The actual R&D expenditures were even higher than the cited ratios as their financial situation became better and better in practice (see Table 6.3).

Table 6.3 Ratio of R&D expenditure to sales revenue (telecom-equipment sector)

Groups	Firms	2001	2002	2003	2004	2005	2006
Group-A	PTIC	2.96%	0.95%	0.91%	NA	NA	NA
	Panda	0.52%	0.88%	1.60%	1.18%	1.18%	1.24%
	Beijing-international	2.90%	4.10%	8.06%	4.81%	-	-
	Shanghai-Bell	5.60%	5.25%	5.81%	7.10%	7.29%	7.60%
Group-B	Huawei	13.62%	18.79%	17.75%	14.67%	12.53%	10.11%
	ZTE	11.96%	10.34%	9.49%	7.63%	9.92%	9.08%
	DTT	11.79%	12.33%	6.23%	-	-	-
	WRI	-	6.51%	5.37%	6.51%	4.70%	5.49%
	JinPeng	1.33%	1.00%	2.22%	2.77%	3.01%	6.78%

Source: calculated by using the information published in the "Top 100 Chinese ICT firms" lists of MII

Therefore, the narrow-sense definition of "absorptive capacity" measured by the quantity of R&D

[102] For example, FAW was arranged to merge two governmental research institutes in 1979. Before that, it had only one product office and one design office as development forces, both small as sub-department units. The new R&D centre of FAW built in 1979 consisted of three parts: in addition to the design office of FAW and the Changchun Materials Research Institute, the largest part was the Changchun Automobile Research Institute, which was founded earlier than FAW in 1950 and was the largest national research institute specialised in the automobile technology. Even in the early 2000s, the R&D centre of FAW was still the largest in the Chinese automobile industry with nearly 2000 employees among which over 1300 were S&T personnel. It ranked the 5th among all governmental research institutes in 2002 with 1000 "S&T achievements" in total, 200 of them awarded by ministry-level or higher governmental bureaus.

[103] For the deficit of Shanghai-Bell before 1988, this clause was in effect practised from 1989 on.

investment could not disclose the source of poor performance of the in-house R&D workforce of Group-A firms in terms of systemic product or complex technology development, which was especially distinct compared with the Group-B firms in their early phases. The hardship of Group-A firms on this score originated more from internal organisational barriers.

For the localisation of imported models, foreign experts led or supervised most product adjustment projects carried out locally. Further, since the foreign sides owned the *inspecting and confirming rights* for any technical change based on original imported designs, they rooted out the possibilities for in-house developers to initiate product development projects based on imported designs even of their own conception.

As for the production localisation, generic activities acted as the central arena of collective learning by occupying the main workforce and investment. However, as always, the gatekeepers of segmental organisational units reduced the in-depth cross-boundary communication with external units because it contradicted their learning targets. Even within segmental units, heterogeneous ideas were not welcomed. Rather, learning was directed to generate outcomes that converged towards imported designs. The knowledge search implemented by participants was strictly restrained within a very limited neighbourhood centring on the imitation of original designs. This system brought about organisational barriers for in-house R&D forces to mobilise relevant learning from these teams and departments, and much reduced the diversity of knowledge among relevant members. Additionally, the learning tasks of production localisation were divided and carried out by different segmental units, departments, and even externally associated firms. Such a structure of labour division added to the difficulties in quantity and quality for R&D personnel to overcome if they wanted to integrate the learning activities carried out by each organisational unit. In fact, it was almost impossible to realise without authorization and cooperation from the highest level since in Group-A firms there were no institutionalised arrangements to facilitate the R&D personnel to overcome the above organisational barriers.

Therefore, in Group-A firms, organisational barriers were set, even if unintentionally, for the benefits of static professionalization. Without any corresponding institutions to help them, the in-house R&D staff were hardly likely to mobilise resources and workforces for learning from other departments or associated firms. However, as recognised by some scholars, development should not be thought of as the application of scientific knowledge, but incorporates engineering knowledge from many sources (Rosenberg and Steinmueller, 1988, p232). The knowledge accumulation based on industrialisation processes is necessary to realise the robustness of product development. However, in Group-A firms, the potential in-house integrators of learning were impeded or even isolated from their laboratories and scientific knowledge by a series of organisational barriers.

For the product development projects launched in Group-A firms, that did not happen often, nor was the situation improved much unless corresponding organisational systems were changed. Since the in-house R&D forces had rare impacts on the decision-making, the learning pattern would not be developed to allocate and apply resources and to schedule cooperation according to the demands centred on R&D personnel for development in real time (if they knew about these). Ironically, under such a system, even the R&D workforces themselves would be also incorporated into a similar specialised but rigid system to the engineering departments. The case of *JiaBao* was a good example of this (see TextBox 6.1).

TextBox 6.1 *JiaBao* project of FAW

The *JiaBao* was minibus model launched by FAW. For its first batch of formal products, side-roll happened when the vehicle passed sharp turns at high speed in case of slippery road conditions.

When this model was developed since 1996, an inter-departmental team was organised. However, since resources were firmly controlled by the top-down hierarchy, and practical tasks were implemented as department-based, the members of inter-departmental team were just representatives of departments, and the practical function of this team was just to assign resources and tasks. Hence, when several testing engineers did realise the hidden trouble of side-roll[104], they had no official way to request specific technical experiments that would cost time and resources, and cause a series of technical revisions relevant to many departments. They even had no official channel to pass this thought upwards since it was related to the systemic design and was already beyond their limits at that stage. People around were also reluctant to respond seriously, since most front-line engineers were also unable to stimulate such a big change, and then they just avoided to be the trigger to a risky "expensive" trouble. Finally, when the message was informally passed to the top manager in charge, it came just as a rumour. The commander neglected it as a rumour coming up without serious technical details. But ironically, in such an organisation, before the problem was seriously identified, the specific testing scheme would not be authorized with resource support to generate corresponding codified details.

Thereby, although it might not be intentionally arranged by Group-A firms, in-house R&D forces were practical marginalised within their organisations. Considering that, in addition to participating in adjustment projects, R&D forces turned to get self-satisfied with initiating projects within their mobilisation range, such as "basic research" or other fragmentary projects, as we pointed out in Chapter 5 (see the Subsection 5.2.5), which were certainly away from the learning activities carried out by other departments based on practical engineering tasks.

[104] They found systemic developers had adopted the "disc-brake" rather than the "drum-brake". Based on uncodified experience of theirs, side-roll would likely happen under particular conditions considering the dynamic system and the weight distribution of this vehicle.

The practice of Group-A firms could be worse. For the gradual shift of strategic intent and the growing pessimism over indigenous product development, the authority of in-house R&D forces in Group-A firms had not been broadened, rather been narrowed. In DongFeng, since the firm continued setting up new productive JVs with MNCs, its in-house R&D forces were disintegrated and allocated as assets to JVs piece by piece to do model localisation, technical testing and other similar activities. It only kept almost the minimum forces in reserve for the development of electric- and military-use vehicles, which were appointed by Chinese government as the read-line for DongFeng.

6.2.3 Knowledge database and supportive institutions

To study the knowledge accumulation systems that domestic firms established can help to analyse their institutional arrangements for knowledge generation and accumulation. We categorise the relevant arrangements into two groups: one is the devices constructed, in other words, the foreground institutions to direct knowledge accumulation; second is the backed mechanisms developed to ensure and enhance knowledge accumulation. In general, Group-A firms had not developed the "comprehensive knowledge databases".

6.2.3.1 Facilities for knowledge accumulating

In Group-A firms, there were no general database opened broadly to general front-line practitioners. Knowledge was collected by chief experts and administrative managers of specialised segments, and along the practices of production localisation the collection of intellectual outcomes was selected. The knowledge integration from the segment level to the factory level was accomplished by chief experts of segments and the corresponding factory, with the associated of specialised technicians The SECI process for most engineers, technicians and workers was limited within their segments. As for broader scope of organisation, the frequencies and intensiveness of SECI processes of knowledge conversion fell sharply.

At firm level, the "product office" or "technology office" was the place to build up the knowledge database both for blueprints of imported models and for in-house accumulated experience. As for the imported models, as mentioned, Group-A firms were not offered full sets of blueprints, but only those parts that were relevant to the manufacturing tasks that were really carried out locally. As for experience gained through production localisation, the keepers did not integrate or further process the collected information. Rather they just edited them. Their inaction as knowledge integrator was partly due to their inability since these specialised "knowledge workers" were far away from practical activities and relevant SECI processes, in addition to their lack of motivation and resources as support. So experience collected was generally represented as un-compiled documents and well-edited "*operational handbooks*" or "*operational manuals*". These manuals and handbooks were accessible to general organisational members, but they included only summaries of experience about processing engineering and operational managerial approaches. Seldom information about the development of product and relevant complex product technology was included for the lack of relevant activities. In some Group-A firms, the "operational handbook" was even only the localised or edited version of the handbook or manual of their foreign partners since they were short of effective knowledge accumulation or confidence.

In recent years in some prominent R&D centres of Group-A firms, such as the Pan Asia Technical Automotive Centre Co. (PATAC) of SAIC-GM, in-house R&D forces began to collect technical information on competing products. However, the data they collected were only those originating from mapping such products, which were rudimentary in terms of both technical depth and breadth. Particularly since the practitioners did not have to make trade-offs among the massive technical details within the complex system under any pressure of carrying out real product development in-house for practical product projects, they were insensitive and inefficient at searching for and locating underlying technical details during the reverse engineering. These capabilities could not be improved unless they had real product development experience as with learning by doing. Besides, the building of product knowledge accumulation in this way had little connection to engineering experience gained through production localisation because neither side had the motivation or organisational channels to do so.

In fact, since the learning practices were costly regarding the time and resources consumed, the accumulation of knowledge was again related to matters of governance and resource allocation. Since resources were not allocated for implementing the development of systemic products and complex product technologies, there were hardly opportunities for Group-A firms to establish strong databases in these domains. Their development in some Group-A firms is summarised in Table 6.4.

Table 6.4 Knowledge database development of Group-A firms

Firms	Comprehensive knowledge database	Notes
FAW	No. Only for manufacturing and localised projects.	Only blueprints of imported models and data on localised adjustment were retained; blueprints of imported models were incomplete in terms of technology; experience based on manufacturing operations was accumulated as manuals.
SAIC	1- No (SAIC-China) 2-Yes (SAIC-UK Technical Centre Limited), but only for the UK part. 3- Yes (SAIC-SsangYong), but only for the SsangYong	Regarding SAIC-China, similar to that of FAW, though manuals were partly based on translation of foreign original copies. Regarding SAIC-UK, there was no official regularised channel for sharing knowledge with SAIC-China. Regarding SAIC-Ssang, the policy of SAIC was the same as SAIC-UK. Now SAIC has lost even operational control of this firm.
DongFeng	No. Only for manufacturing and localised projects.	Similar to FAW. Moreover, the IPRs were supervised by the foreign side.
Shanghai -Bell	No. Only for manufacturing and localised projects.	Similar to FAW

6.2.3.2 Arrangements to promote knowledge accumulation

The mechanism that upheld the knowledge database building of Group-A firms was primarily interwoven with their other institutional arrangements for organising learning. Their relationships with foreign partners led to an inability to obtain full sets of blueprints and technical data of imported models, and so Chinese engineers lost their dominance in most local product adjustment projects. Their authority over strategic resource allocation, having marginalised the in-house R&D workforce for product and relevant technology development, led to its difficulties in mobilising resources from other departments for integrative learning. This point also relates to their learning organisational patterns that separated R&D from production localisation practices and divided the latter into specialised individual segments. The knowledge gatekeepers were set up to maximise static professionalization of the learning activities for production localisation, but on the contrary impeded the range and extent of organisational activities with which central knowledge databases of firms could deeply interact.

Without changing the above institutional arrangements accordingly, the knowledge accumulation mechanisms of Group-A firms could not be substantially promoted for the benefits of generating systemic understanding of product and complex product technologies.

The situation for some Group-A firms in practice could be worse. Take DongFeng as an example: after setting up the JV with Nissan in 2003, it lost most of its in-house R&D personnel as an independent team to employ. Within DongFeng-Nissan, according to the JV contract, the foreign side stipulated clearly that the "*information officer*" post of the newly set-up R&D centre must be assigned by Nissan. Thereby, it was impossible for indigenous subsidiaries of DongFeng to obtain any direct technical spillover from DongFeng-Nissan. The new R&D centre became a pure information deliverer, serving concerted production localisation.

SAIC presented another extreme. It could access three large databases, but it had not effectively utilised them. Firstly, PATAC, the R&D centre jointly held by SAIC and GM, could access and work on the global database of GM. However, since the database was GM's exclusive property, GM strictly supervised every project based on it, and forbade it from being used by or diffused to any projects that might raise competition against GM. So using this database, what PATAC could develop were concept cars that were far from being industrialised. Secondly, through equity purchases, SAIC acquired the technical database of MG Rover and SsangYong, but SAIC had not built up any effective linkage in terms of knowledge sharing or developmental activities in real time between them and the R&D or engineering forces in China. As to the SsangYong case, the database was closely supervised by the Korean workers' union to prevent knowledge from being transmitted to China[105]. The database of MG Rover and PTL was built into the core asset of the SAIC-UK centre. But until now, this centre has been held in trust by Ricardo as a quasi-independent technical service firm to SAIC, and there was no sign that tight connection of developmental activities would be built to link potential counterpart activities in China.

The situation for Shanghai-Bell was somewhat different. Since it could provide customised network solutions for local customers, this brought some related accumulation. However, as mentioned above, it was separated from the development of products adopted in its network solutions, which came from its partner MNC[106]. Other telecom-equipment Group-A firms seldom worked as independent bidders in the market, and correspondingly they did not have any independent database about product development or significant technical development.

6.2.4 Analysis: specialised and rigid organisational learning systems of Group-A firms

Group-A firms had thus transformed their organisations for facilitating production localisation and relevant technological learning under the TMFT framework. For the first-movers among Group-A firms, such organisational transformations were carried out under similar circumstances, namely the governmental expectations, the attitudes of the foreign sides, the financial concerns and their own views embedded in social cognition about technological learning and catching-up at that time. Even though there is no direct evidence that any Chinese authority ever tried to persuade Group-A firms with details of learning patterns except for the general model introduced in Chapter 4, the organisational systems of Group-A firms turned out to possess great similarities. That is, the developers of systemic product and relevant complex product technology were marginalised in decision-making for strategic resource allocation. Learning through production localisation was carried out by a specialised and rigid system that could facilitate the efficiency of mastering production skills within the pre-determined technical and organisational structures, but was fragmentary in organisational mobilisation and learning integration. Knowledge databases were built up without purposeful integration between manufacturing and product-oriented R&D, and among different segments. Heterogeneous thoughts relevant to product and technical systems were depressed along their learning based on production localisation practices. Thus, with carrying out activities buttressed by such organisational systems for long, their intent of technological capability building has also gradually faded away.

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[105] But for the tough strike which has been raised by Korean employees started before SAIC's entry and has lasted over 3 years. SAIC gave up management authority over SsangYong from Feb 2009.

[106] Certainly, considering the change of its dominance to Alcatel from 2001, as a substantial body of Alcatel-Lucent, there are signs that very recently some functions of Alcatel-Lucent's global R&D would possibly be transferred in, which is to utilise the local R&D strength brought by Group-B firms and being recognised in recent years, and also one part of the wave of MNC's utilising Chinese local R&D workers in some industries from early 2000 (Xue et al. 2002).

Here, for discussion based on the summary of Group-A firms, we have two points to stress. Firstly, we must point out that building their kind of organisational systems was primarily a question of cognition, selection, and then implementation. Such a process must be associated with cognition, investment, organisational cohesion, trial-and-error practices and accompanying organisational capabilities. Otherwise, it might seem that to improve the efficiency of technological capability building, Group-A firms only needed to set up new arrangements according to some guidebooks about advanced management.

Consider the case of the "*SanKouLe*" model, by which a minicar model was spontaneously developed by a dozen of FAW engineers without official permission (see the Appendix-1). When this project was exposed to FAW's authority as a technical success, the president of FAW at that time was to give relevant engineers an award. However, other executive managers and common engineers opposed this proposal, and their reason to deny it was in the name that such an award would distract the attention of the whole organisation from stressing the production localisation in process of *Audi-100*. Thereby, participants of *SanKouLe* on the contrary got a serious official warning instead. In this case, the volition of the FAW president was overwhelmed by the existing organisational learning system, including the other top authority holders, the middle-level of managers and technical chiefs and the organisational culture.

Starting from this point, to change the system, potential reformers not only had to deal with the organisational inertia, but also had to work out new pattern of learning. Reformers must get effective support based on organisational cohesion to realise the "*Pareto improvement*" with two targets as promoting production localisation and in-house technological capability simultaneously. However, the leaders of Group-A firms themselves did not have relevant experience; and they had seldom colleagues around who obtained experience or knowledge of this to consult. This might be dissimilar to the circumstances in general in industrially advanced countries. In fact, before the success of Group-B telecom-equipment firms became to be recognised in the 2nd half of 1990s, the Chinese industrial community had not experienced significant success with such a "dual-target" in mass manufacturing civil industries. Therefore, at that time if Group-A firms leaders could not invent, they would also have not domestic first-mover samples under the same or similar external conditions to follow about how to translate their intent into developing such ambidextrous organisations. The fact was that there had not been any substantial collective move or attempt among Group-A firms in these two sectors to carry out organisational reforms for such a change.

Secondly, considering Group-A firms' organisational learning patterns, we encounter a "what" question regarding the SECI process of knowledge creation. As the SECI process is based on the communication and "learning by doing" activities of organisational members (Nonaka and Takeuchi, 1995), the outcomes of "knowledge to be created" are certainly related to their communications and activities. Therefore, the efficiency certainly matters, as we can see among most Group-A firms the learning about manufacturing was quite successful, but the input control, process control and relevant institutions should also be questioned at the foreground of studies. Questions about who controlled the resources for the SECI process, who were mobilised and what information was allowed to be loaded are not negligible.

To explore these questions, we still need to dig more empirical evidences, as what we will do regarding the cases of Group-B firms. Anyway, based on analyses on hand, we can figure out that conventional advocacies of bottom-up technological learning patterns for DCs usually entail a series of presumptions that might not have been pronounced by their advocators. For example, "the activities corresponding to the practices of lower-level capabilities could generate higher-level knowledge", "the decision-makers of firms contain sufficient motivation, knowledge and ability to mobilise their organisations to achieve capability-building", and "corresponding organisational learning processes are well integrated", etc. According to our analyses of Group-A firms, these presumptions should not be taken for granted, although we are not simply to deny the practices of bottom-up trajectory.

6.3 Organisational learning systems of Group-B firms

In this section, we follow a similar structure of the last section to explore the organisational learning systems of Group-B firms.

6.3.1 Authority over allocation of strategic resources

Persistent strategic intent regarding the in-house capability building had Group-B firms advance with sizable stretch coming from the gap of their current capabilities and resources with the ends of their organisations (Hamel and Prahalad, 1989). Correspondingly, institutions built to address the strategic resource allocation were required to ensure a long-term commitment to technological capability building and to realise the appropriate efficiency of technological learning.

By comparison with Group-A firms, the R&D personnel had substantial influences in decision-making of Group-B firms. Since most Group-B firms were new entrants and not included in the TMFT framework, the in-house product development was the basis of their business. Their strategy to run the product-oriented competition (see Section 5.5.3 in Chapter 5) also urged the developers of systemic products and relevant product technologies to be located in the centre stage of the strategic resource allocation and tasks scheming. It was because R&D personnel obviously had advantages in identifying and comprehending activities related to the product and technology development, particularly considering that in the domestic industrial community, the relevant experience did not exist prevalently. Besides, the authority structures within Group-B firms were also closely path dependent. As Group-B firms all grew up from small organisations led by their original product and technology development teams, core members of these teams did have more opportunities to participate in decision-making. For example, ZTE was built by a spin-off team from the "Technical Office" of the No. 691 factory affiliated to Ministry of Aerospace Industry. HaFei Auto was a the spin-off team from the R&D centre of HaFei Aircraft. Huawei was an entirely newly set firm in the private sector, but its earliest core of organisation was also a small product development team[107]. After they were set up, Group-B firms had to survive through a series of challenges by having their products be competitive, and by expanding the breadth and depth of knowledge in response to rapid changes of the industries. The relevant experience also enhanced the significance of R&D personnel within their organisations. However, we cannot regard the dominance of R&D personnel in strategic resource allocation as an easy arrangement to recognise, select and implement by organisations. It could entail intensive organisational conflicts and struggles. The case of authority contest in Geely exactly presented this point.

Geely started as a family-control firm led by LI ShuFu. Around 2001, other family members by blood quitted its car-making business since they regarded it as high-risk[108], which gave LI a chance to reform the firm. Experienced engineers and technical managers were introduced from outside and a somehow "dual leadership" management system was formed for its regional bases[109]: the finance and routine managerial operations were supervised by a general or deputy general manager from the LI's inner circle. Meanwhile the strategy making at least regarding the R&D relevant activities was led by an experienced manager with technological and engineering backgrounds that Geely recruited from external. Besides, a central R&D centre was built up as the heart of Geely as for the mid-term and long-term product schedules and the development of complex technologies, which was also led by professionals. Therefore, the legacy of family control supervised the money flows and the comparatively static operations; meanwhile the professionals led the dynamic parts, i.e. the product and critical technology development and the relevant expansion of production capacities.

However, it did not mean a complete transition of the organisation. A conflict about the supply chain happened during 2004-2005, with the contradiction between the family-control legacy and the professional force lying behind. A reform was generated only with the intervention of Li with his absolute authority, and only because it came to a vital occasion entailing "life or death".

TextBox 6.2 Contest about the reform of the first-tier supply chain of Geely

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[107] Certainly, in order to raise their initial capital, they both had several years' history in running other business. Huawei did agent sales of imported PDSS, and ZTE did OEM manufacturing of electronics.

[108] Later, one other family member also ran a car-maker that manufacturing *Alto*, namely the model imported from Suzuki.

[109] The structure of Geely could be regarded as one central R&D centre and six regional bases (data from 2008). Each base had fully functional administration from R&D, manufacturing, marketing and post-sale services.

During 2004-2005, Geely was in difficulties for the insufficient qualities of components provided by a number of its first-tier suppliers. The component problems delayed the developmental process of ongoing product developmental projects, and caused bad performances of existing product models launched on the market. Professional engineers and technical managers could not tolerate the situation, and proclaimed a reform upon the supply chain. However, it in essence challenged the tradition associated with the force of family control.

Quality problems happened to many first-tier suppliers which had quasi-permanent cooperation with Geely since Geely still focused on its motorcycle and building materials business (from 1994, and the late 1980s respectively). For long-term cooperation and cross-shareholding, they had in fact become an extension of LI's inner circle, and showed cohesion to follow Geely by taking the risks to enter the car-making business since 1997. Thereby, many executive managers standing for the family control force opposed this reform and raised a server controversy on the top committee. They claimed in the name of stability that for the public identification of Geely as latecomer, it was difficult to find other close co-operators for sharing the risks of product development. Finally, LI and one vice president (from his inner circle as well) voted to support the reform and entrusted the reform to a committee dominated by professionals. Through the reform, Geely eliminated bad-performing suppliers, and imposed supervision on the governance and technological management of other first-tier suppliers at least for temporally.

The scheme cost in total two years for Geely to realise. A few top managers got demoted in order to make the reform work, while the authority and manpower of professionals with technological and engineering backgrounds were enhanced to realise the control schemed by the reform. Finally, with the significant raise of professionals in the top committee, the reform developed Geely away from being attached to inner-circle benefits, and changed the mainstream organisational values. LI and his core followers still had critical influences for their shareholding, but they control the strategic direction of business development only, and entrusted the authority of general resources investment to professional managers. It formed up a mixed structure of corporate control, and showed effective in guiding product-oriented innovation.

We list the structures of top committee in Group-B firm by the table below. We can see that developmental engineers led Group-B firms. Even only counting in the committee members with experience of product development in recent years, they also had substantial influences for decision-making.

To take Chery as an example, in 2007, among 9 members on the "managing and decision-making committee", namely the top committee of Chery, only 1 represented the central R&D centre which was similar to the situation in FAW. However, except for the 1 representing finance, all the rest 8 members had engineering and technological backgrounds, even including the 2 from the human resources division and marketing division. In fact, other than the 1 from the marketing division, all the rest 7 had ever participated in product development in Chery's early years.

In fact, even mentioning the front lines, Chery was also dissimilar from Group-A firms. In 2006, there were about 4,000 engineers employed by Chery. Among them, 1500 engineers could be mobilised, without attachment to production lines, to take part in new product development, which was unimaginable regarding Group-A firms.

Table 6.5 Structure of Top Committee of some Group-B firms (2007)[110]

Managing and Decision-making Committee	Chery	Geely	HaFei	ZTE	DTT
Total number of members	9	11	9	22	9
-Members with technical or engineering background	8	6	7	18	7
--Members with product development experience in corresponding sectors	7	5	6	14	6
---Members with corresponding experience in the past 2 decades	7	5	6	14	5

6.3.2 Learning organising pattern: cross-boundary inter-departmental platforms

The institutional arrangements of organisational mobilisation and learning integration address the question that through what kinds of mechanisms learning is carried out among organisational members of firms, and individual learning is tied for collective and purposeful (but not certainly appointed by top-down authority) targets. For this topic, we concern the organisational integration that firms achieve enables them to "*socialise participants in a complex division of labour to apply their skills and efforts to the achievement of common goals*" (Lazonick and West, 1995, p231). As latecomers, new indigenous firms had to mobilise their members and resources as much as possible to maximize efficiency in making use of what they possess. Clark and Fujimoto (1991) also emphasize that early and integrated problem solving is the key for performance of product development. As to the industrial environments which Group-B firms were located in, Chinese previous industrial administration divided the relevant industrial practices into a highly specialised but rigid system. However, the international competition emerging along the reform and open-door policy obviously did not follow this logic. Then Group-B firms must assimilate intellectual resources from different industrial domains, and integrate learning inside their organisations or cooperative networks.

Then how the firms achieved effective organisational mobilisation and learning integration come

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[110] The data of Huawei is not included in this table for its special organisational culture. Firstly, Huawei is an engineer-led firm without doubt, represented by absolutely advantage of engineers in the EMT. Second, Huawei is an innovative firm upholding heroism engineer culture. Its founder and godfather REN ZhengFei, who ever pushed all the critical product development in Huawei's even only had less than 2% stock share, had absolute authority. Underneath him, two legendary engineers, namely ZHENG Baoyong and LI Yinan who were both REN's protégés, were respected with authority in practical development organising in 1990s. Now the chairman of board, namely SUN Yafang who in fact is the assistant fellow to REN, also had engineering and technical background. Thirdly, based on the last point, the real authority distribution and evolution of Huawei's EMT were quite flux, and hardly to be clarified by structural data simply. Therefore we do not list it in.

out as a question. In addition to the learning held by professional departments, the cross-boundary inter-departmental platforms worked significantly as to the technological learning in Group-B firms. We take a time sequence to discuss this topic.

6.3.2.1 Inception stage

In their inception stages, technological capabilities of Group-B firms were based on competences of individuals who came to participate in their organisations generally from different places. Therefore, organisational integration was urgent for generating effective capability-building. As the size of Group-B firms was small at that time (see Table 6.6), it was not difficult for their leaders to work on mobilising the organisations. In fact, most leaders of Group-B firms worked as practical chief engineers in their inceptive stage, even including Li ShuFu, the founder of Geely, who had not obtained technical automobile knowledge before.

Table 6.6 Approximate number of organisational members of Group-B firms in the year of starting the projects for their 1st industrialised product model

	Chery	Geely Auto	HaFei Auto	Huawei	ZTE	Xinwei
Number of members	35-100	30-100	30	20	100	30-40
Year of data	1997	1998	1983	1990	1988	1995

The case of Chery is taken to demonstrate the mechanism of organisational integration in the inception stages of Group-B firms when official binding arrangements were still crude.

The inceptive organisational configuration of Chery comprised three main parts. First, there were about 10 founding engineers recruited by investors from automotive components makers and governmental bureaus. They were good at supply chain development, plant construction, public relations, and so on. Second, there was a group of engineers recruited from FAW. Yin TongYao, its president and later chairperson, was the first to be attracted by Chery. The other young FAW engineers came to follow Yin from good personal relationships. They had been trained together overseas by a p associated with the setting up of FAW-Volkswagen, by which FAW aimed to cultivate the second-tier backbone engineers among the young generations. Thereby, their participation significantly promoted the capabilities of Chery in manufacturing. Moreover, there was another group of retired engineers from FAW invited by Yin and his colleagues since most of them had been supervisors or senior fellows of Yin and his peers in FAW. Most veteran engineers had become skilled before the prevalence of TMFT, and had experience and memories about systemic product development before. Therefore, in addition to the manufacturing capabilities, they contributed to Chery on the systemic configuration of products, and the development of engine models, and so on, although they also did many of these tasks through trial-and-error. The third part was made up of engineers who were recruited from other domestic vehicle-makers, mainly from the makers of agricultural vehicles and modified trucks[111]. Several of them were classmates at Yin's university. They had rough product development experience of vehicle development, including product system configuration, chassis engineering and bodywork design.

Therefore, in the inception stage, a basic development team was organised to fulfil different functions of car development, relying on integrating individual competences. Certainly, Chery pursued professionalization by developing professional departments, but in terms of knowledge creation, organisational members were not fenced in by strict boundaries. Rather, they worked together with intensive interactions, entering each other's realms in the process, which enabled them to master the development of contextual subsystems and components in real time. Doing so exerted the capabilities of each individual by exposing an open development process to most participants, and to some extent remedied the weakness of their overall possession of competences, especially the lack of experience in systemic product development.

The shared strategic intent among members and hard-working spirit were important for achieving organisational cohesion. As already seen, the founding members left their previous posts and stable or even promising careers to join Chery, just to seek something different from their previous experience under TMFT. Besides, the core leaders[112] worked as roaming institutional agents to mobilise different units. They personally participated in most projects during this stage; their intimate relations with most founding members promoted the effects of their coordination and authority to overcome conflicts among units, and realised high efficiency of information flow and resource allocation.

As for patterns of organising learning, Chery did not have existing technical targets for members to follow. Rather, it was for each participant unit to determine the directions, essential features and specific details of designs in their specialised fields. The reasonable nature of this pattern was supported by the institutions of resource application, i.e. corresponding resources were entrusted to each unit. Certainly, Group-B firms also implemented budgetary systems. However, the budgets derived from exogenous financial restrictions were mainly responsible for directing the detailed learning practices. Only when the application of resources was controlled by front-line units could they fulfil the responsibilities of coping with the uncertainties associated with

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[111] There had been indigenous product developers in these two segments because relevant licence regulations were not strict since the regulators did not regard them as important sectors. Thus very basic product development capabilities had been indigenously developed. Agriculture vehicles were a specified type designed for transporting passengers and goods on bumpy roads in the countryside. They were similar to pickups but much simplified and cheaper. By contrast for cars in general, they adopted small diesel engines but strong chassis; thus they ran slower but could carry a lot (usually overloaded), and omitted many accessories to save costs. Modified trucks were produced based on truck chassis that makers outsourced, and with bodywork developed in-house, most of which was very rough. Usually, modified rather than standardized trucks were developed, for niche markets.

[112] The three core members were XiaLai Zhan, TongYao Yin and JianHui Lu. Zhan, representing the investors, n was the founder and first chairperson of Chery, also the deputy mayor of Wuhu City where Chery was located. He was regarded as the moral leader even after officially resigning from Chery. Lu was the chief engineer of Chery before 2004.

effective technological learning in real time, and then communications engender in-depth interactions among them during the process of learning.

For example, when the first prototype of Chery's first car, the *Fulwin*, was coming out, the engineers in charge of the supply chain reported difficulties in finding suppliers to participate in the development of chassis assemblies. The engineers in charge of plant construction and equipment development quickly advised adopting some interchangeable components from the local supply network of *Jetta*, because they personally knew the *Jetta* system well and had good contexts with some second-tier suppliers for their experience in the production localisation of *Jetta* in FAW. Following this advice, the engineers in charge of system configuration brought in a *Toledo* (1991 version) from SEAT which shared major technical features with the *Jetta* as the target model for this adjustment. Through close interactions, other departments also adjusted their designs accordingly, so did the units responsible for industrialisation preparation. Thereby, even with such a change, Chery still succeeded in launching the final prototype in 1999 as expected. During this activity, the core leaders mobilised each unit to work for the collective aims although the aims themselves were also dynamic. The front-line engineers were encouraged to be involved in a broad circle of knowledge creation within the organisation and across departments, and were energised with entrusted resources to generate their solutions just-in-time.

The pattern of Chery in mobilising its organisation and integrating the collective learning should be highlighted by comparison with the pattern of Group-A firms. In FAW, when its *CA6DFx* series truck had been scorned, customers required an adjustment to add two footboards outside the cabin doors, otherwise with the original design drivers had to step on the front wheels to enter the cabin, which was inconvenient and even dangerous under particular conditions. The FAW official accepted this suggestion, but it still cost 6 months for FAW to adjust simply the blueprints. Much time was spent on communication, liability classification, task layout and resource allocation. In fact, informal communication among engineers was not problematic since as a legacy of housing welfare of SOEs, the engineers of FAW lived close together, which permitted informal communications. However, informal communications proved unable to supply the formal "*Ba*" of work coordination and technological learning. Further, since front-line engineers and units did not have resource authorisation, their communications were inefficient unless relevant projects had been schemed by the top-down authority. Here, some might argue that it was because the Group-A firms were too big to be flexible. However, in my view, it was because too few people could make decisions rather than the situation in Group-B firms that many people could make decisions for their own parts. Group-B firms insisted on this even when they had grown and had larger R&D workforces than Group-A firms.

6.3.2.2 After the inception stage

After the inceptive stage, cross-boundary platforms were still the major arenas on which Group-B firms carried out developmental tasks and technological learning. To realise the organisational mobilisation and learning integration, both informal and formal arrangements had been developed.

(1) Informal arrangements

Many informal institutional arrangements used in the inceptive stage remained. New informal arrangements were also developed to promote the interactions among organisational members and across the intra-organisation boundaries that were set for professionalization. We just list some of the informal arrangements that might be not popular in the literature here.

In the telecom-equipment sector, a tutorial system was implemented, which initially was set to accelerate the cultivation of junior engineers. Later, since the personnel flows across departments were quite frequent, tutors were often in departments different from those of their students. This situation was found to be even more helpful in promoting the breadth and depth of students' knowledge and helpful to enhance coordination among different units than what was originally expected. As a result, this tradition was solidified as a life-long arrangement for newcomers.

Besides, in order to activate and diversify the knowledge creation, Group-B firms invented a "free-recruitment" arrangement. The arrangement allowed project managers to recruit members across the departmental boundaries by posting advertisement. Specialised departments were also encouraged to post advertisements for solutions regarding the technical problems they could not fix. Further, engineers were encouraged to establish project teams aiming at particular attempts, only if the initiators could pass the examination held by a panel sent by the corporate technology and product committee. This tradition not only meant to encourage learning cross boundaries, but was also used to maximise the intellectual *services* generated by the in-house talents.

In the car-making sector, Chery invented a tradition that on the last weekend of every month, high rank managers would test-drive the cars under developing (usually several dozen in number), with development engineers sitting in passenger seats. By doing so, opportunities were provided as for the direct communications between front-line developers and corporate decision-makers, and to prevent problems and appeals from being shielded by the hierarchy or departmental boundaries. The relevant effects went beyond the limitation of time and locus of test-drives. At any spare time, development engineers would try to chase the corresponding high-rank managers to check their improvements upon the problems or advices put forward by the managers, because a competitive atmosphere had been formed up among the development teams for the publicly "problem displaying and improving" effects associated with this tradition.

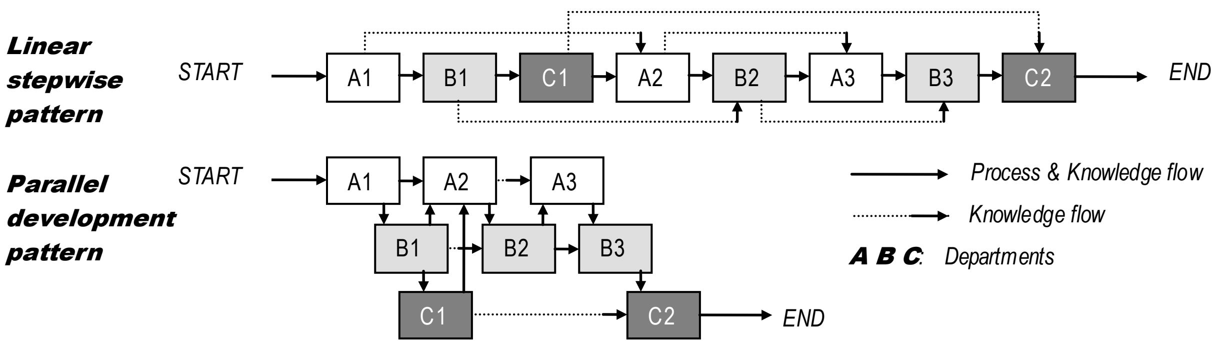
Certainly, Group-B firms also generally adopted the job rotation, as an arrangement to maintain the flexibility of organisations. In Huawei, for high-level managers, the firm insisted an informal post rotation for every 2 years.

(2) Formal Arrangements

Formal arrangements were established gradually by Group-B firms. A series of them were constructed to ensure the cross-boundary inter-departmental platforms of development and learning. Accordingly, a significant part of power for resource allocation resided in coordinators of these platforms. In this section, we organise our analyses by longitudinally depicting their general pattern of tasks processing, namely the "parallel development pattern". The "parallel development pattern" contrasts with the linear stepwise pattern, and means for a specific project, different departments carried out their respective portions in parallel if possible. This pattern is set to shorten the time to market of new product developments (see the figure below). For example, by doing so, in the car-making sector, the development cycle of frontier car-makers for a new car model has been reduced to 18-24 months currently by comparing to about 48-60 months in the 1980s. The average development cycle for Group-B firms was about 24 months at normal situations during 2001-2006 in reference to the development of their second-generation models.

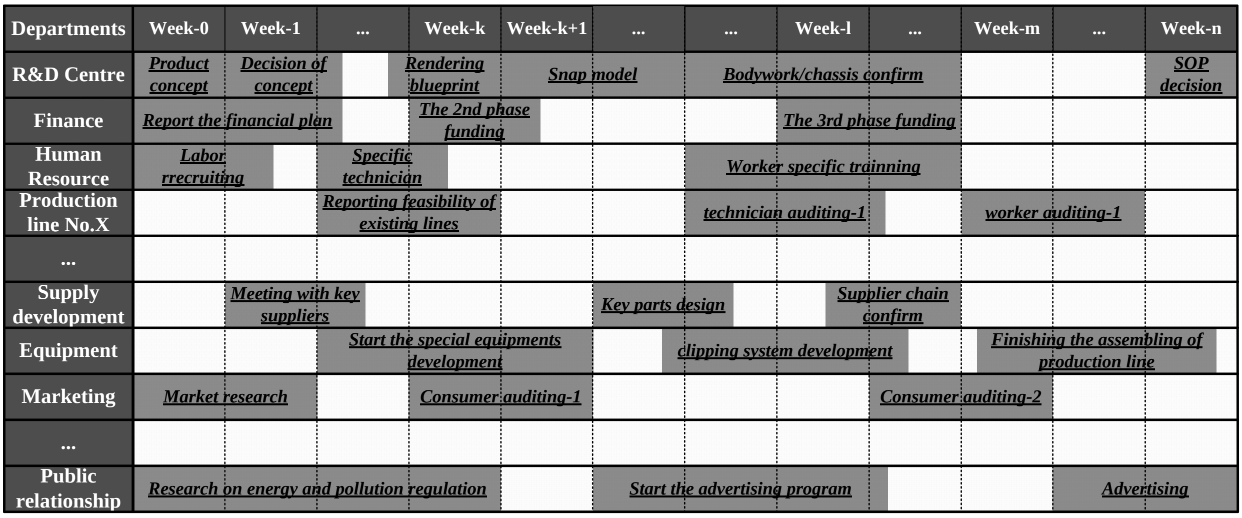
The "parallel development pattern" was not invented by Chinese indigenous firms. Actually, Group-B firms learned it from the global giant competitors. However, the underlying institutional arrangements to ensure effective parallel processing were not codified and could not be easily duplicated from any samples. These arrangements, dealing with scheming tasks, resource allocation and interaction among organisational members, were concentrated in the intra-organisation conflicts, relevant to the organisational path dependence and the distribution of authority. Thus, the realisation of such a pattern was deeply an organisation-specific process.

Figure 6.2 Schema: Linear stepwise model *vs.* parallel development pattern



To scheme the tasks, resource allocation and intra-organisation interaction was the core of parallel development. Although all relevant departments participated in scheming the tasks, in Group-B firms the product and complex technology development teams dominated this process associated with the project management department (or equivalent department), since apparently its tasks entailed the most uncertainty considering the tensions between the capability foundations and ends of Group-B firms in this stage of capability-building. Then in practice, product developers acted specially the kernel role to schedule the time and to arrange the tasks for other departments. During the process, it also worked to connect, mobilise and integrate participants pace by pace. The Gantt chart below schematises a virtual product development project.

Figure 6.3 Schema: Parallel development for a car model (car-making sector, Gantt chart)



Readers might argue that such a pattern was also implemented by Group-A firms. It was true. However, since the interfaces of their learning objectives, which represented by their imported blueprints, had been well-developed between different modules/assemblies, and between different working procedures, the major uncertainties for their learning organising were more located within specialised segments, such as equipment debugging, pace controlling, quality promoting, which also entailed the department-based pre-determined resource allocation. Therefore, they did not impose such significant requirements of intra-organisation interaction associated with the underlying dynamic developmental processes in real time. Rather, they stressed the dimension of time and scale as to the interfaces. The role of R&D force was placed inferior or even disappeared during the scheming of production localisation.

Generally, product development processes can be summarised by three stages. We take a project of new car model development as example.

Stage-1: Planning

Major tasks for this stage are to plan the tasks, style the product and make technical preparation.

[See Appendix-5 for the "Planning Stage"]

(i) Team composition

After the product development directive is made, a small inter-departmental team is organised, raised by the department of project management mainly.

(ii) Inter-departmental communication and interaction

Representatives from different relevant departments attend regular meetings to discuss timing and the approximate arrangement of budgets. Concerns of discussion include the current workloads, technical requirements, feasibilities, and decisions about in-house development and outsourcing. Common knowledge (Grant, 1996) among different participant units began to be cultivated. After several rounds of intensive interactions, the general time nodes are determined.

To style the product and to decide the system configuration are central technical tasks of this stage. Styling engineers transfer the objective of strategic plan into visual artefacts, namely into sketches, digital drawings, clay models and milling models. Then, the system configuration made by general designers establishes a fundamental physical structure with major parameters for participant units to work on. The styling room and the general design department are frequently taken as the locus of discussion. The layouts for different stages are shared among members of the team from time to time in order to achieve the effectiveness of interaction among departments.

This stage defines the general characteristics and functions of the product to develop. Interactions among participant units are necessary to ensure the feasibility of project. It is also a process to connect the new product development with the previous knowledge accumulation, which involves not only the knowledge of specialised segments but also the integrative understanding. Without effective organisational mobilisation associated with this process, the development of new products may divorce from the current capabilities of each specialised domain, and drive the project into crisis of being unrealistic or outdated.

Stage-2: Technical development

The major task for this stage is to develop an appropriate prototype. Relevant departments should have their designs ready for industrialisation. Some tasks for industrialisation are also included.

[See Appendix-5 for the "Technical Development Stage"]

(i) Team composition

A larger team is formed as the product development team including representative engineers from relevant departments. Front-line engineers make up the majority of the development team. Mangers from the project management department transfer into assisting and supervising roles, to control the time requirements and financial budgets of the project.

An inside project-oriented squad is formed up within every department to serve the specific project, and to take part in the inter-departmental team as representatives of their home departments. The representatives played the role of "liaison engineers" (Clark and Fujimoto, 1991, p103) to bridging their home departments with corresponding project teams. Moreover, they also have to act as real practitioners of the project. It does not mean other members of the home department do not work for the project. In fact, even with increasing forces of R&D personnel, Group-B firms in most case face the tension of human resource for their ambitious amounts of developmental projects progressing parallel. In most cases of Group-B firms, engineers in general would attend definitely only one project, but usually several or even dozens of projects spontaneously. Thus, the representative team have to be organised based on the lean principle. Home departments would organise flexible forums to support their representatives in response to emerging technical problems. Home department members, who in fact are also working as representative in other projects, share their knowledge to generate solutions. Further, the representative team may also be flexible regarding its formation. Experts or senior members good at specific domains could be drawn in as members of their representative team to enrich the interaction with other departments for tasks related to their expert domains. We can say members of home departments work together as a group of knowledge-sharers; knowledge gatekeepers, usually acted by technical leaders or senior engineers, are not set to stipulate the boundary of knowledge creation process of affiliated members, but work as coordinators and supervisors to ensure the quality of knowledge output.

Meanwhile, to realise such a matrix-wise learning pattern, budgets for departments are allocated according to both the departments and the projects.

(ii) Inter-departmental communication and interaction

As for the inter-departmental team, weekly meeting is the regular arrangement to push the mobilisation and interaction among departments. One high-level manager, usually a head of department or higher post, is appointed as the nominal leader of the project, while the practical project manager is usually acted by a section chief or a junior vice departmental head. In addition, a group of senior managers, usually vice-heads or junior heads of departments, are arranged to attend meetings on demand. They are not required to be fixed members of the project, but their authority could help to fix problems relevant to the conflicts among departments. Besides, some first-tier suppliers begin to be involved. When technical features of new models are essentially fixed, questions would concern detailed parameters; so for the discussion about the feasibility and economy, suppliers are obliged to participate in relevant discussion.

Interactions among participants could be intensive. Since interconnections are pervasive within the product system among different subsystems and components, it is usually that sources of technical problems about interconnections cannot be 100% clarified, especially considering the immaturity of experience of developers in Group-B firms. In order to persuade the other side(s), various tools in addition to technical reports are employed by participants, including dynamic emulations, digital pictures, videos or even prototypes of assemblies. The intensive interactions, or tough arguments sometimes, make the meetings into technical forums or even technical competitions. But only with the intensive interactions, could shared meaning be produced among different participants (Grant, 1996) through schema, metaphor, analogy and stories (Spender, 1989; Nonaka and Takeuchi, 1995; Brown and Duguid, 1991). Only with the intensive interactions, could knowledge *redundancy* among participants be raised that permits individuals to invade the functional boundaries of each other and causes loose couples among them (Nonaka, 1990; Nonaka and Takeuchi, 1995, p80-81). Of course, compromises would finally be generated among different units under the coordination of higher authority. For some extreme cases, in order to generate temporal consensus and push the project forward, arbitrary decisions would be made by project leaders according to their personal experience and the negotiations with relevant participants. For these difficult points, in order to benefit the future development, recorded special treatments for particular types of problems would be developed by the team, which can be taken as references or remedied by other teams along the future projects. As for consensual progress, the team would record every discussed topic, relevant solutions and other outlines. In the next meeting, every unit has to give an account of the tasks it has been assigned to or proposed in the last meeting.

During this stage, resources allocated special for projects are kept and supervised by the project management department and the nominal high post project leader, but are executed and adjusted among participant units by the practical project manager. Since the budgets for specialised departments are not sufficient for them to carry out tasks appointed, this arrangement yields incentives for them to involve in the learning on the inter-departmental platform actively.

Stage-3: Industrialisation

The major task for this stage is to develop the prototype into an industrialised model. The focus is to work out engineering methods for the manufacturing of the corresponding model.

[See Appendix-5 for the “Industrialisation Stage”]

(i) Team composition

The product development team is enlarged, but altered for its configuration. Product R&D departments gradually hand over the dominance to the down-stream co-operators, but still keep basic seats in the team in order to maintain the abilities of quick response to any emerging requirements related to design adjustment. In-house equipment developers take over the central positions, such as the die developers, production line schemers, machine developers and those for clamp and attached tools, so do the engineers in charge of testing, namely engineers of laboratories and those in distant skid pads.

(ii) Inter-departmental communication and interaction

Meetings take place daily, semi-weekly, or weekly according to the degree of maturation of the project. Generally, the frequency and intensity of meeting increase as the model becomes industrialised. Top managers, namely the directors of the firm, executive managers, and senior heads of departments, are assigned to supervise the meetings in rotation. For some occasions if special problems emerge as urgent, the top manager in charge of the corresponding field would be specially called to host the meeting beyond the normal rotative sequence.

Regular meetings are usually arranged at work-sites, such as in testing laboratories, stamping die developing centres, test-assembly plants and auditing rooms. On-site meetings are convenient for problem solving and the SECI process of knowledge conversion, since many details under development could be still tacit and sticky, and could be better exhibited by presentation or trial.

The interactions are tough and intensive. It is because huge investments have been made, then significant alterations of designs are hardly acceptable, which causes developers sensitive to technical problems. Besides, as the industrialisation proceeds, improvement tasks focus more and more on delicate details, particularly those interlinking regimes of different units. As some knowledge under development is tacit and sticky, these problems must be scrutinized through cooperation. Otherwise, problems may possibly spread and involve more segments. Thereby, top managers are arranged to promote the cooperation and to adjust resource allocation among participants on-site. Mistakes, neglect and relevant responsibilities are exposed, not hidden, since in front of all participants, cooperative units would challenge the explanations and frameworks of each other. Through such a process, stubborn problems are fixed by generating mutual adjustment (Thompson, 1967, p56) and compromise. The authority of top managers is employed to control potential departmental selfishness in such cases.

The way of resource allocation inherits the pattern of last stage. Budgets beyond the resources controlled by the product development team could be offered as needed, if the additional investments are necessary or significant for general benefits of the firm, such as for building critical laboratories, instruments and equipment, workshops or implementing special experiments. In fact, it is an important path to explain the growth of Group-B firms in physical infrastructures.

As we said, the above procedures were typical for Group-B car-makers in their early phase. Group-B telecom-equipment firms implemented patterns similar. The major dissimilar point is the role worked by a “system department”, which is created for the customised essence of this industry. The nominal task of this department is to price the involved customised products. It gives the product development teams the appropriate prices according to the customised technical requirements, or denies the prices put forth by customers. Meanwhile, it also gives the front-line developers clear directions regarding the technical solutions for corresponding deals, such as by informing the teams or departments what (solutions) they really could try. To fulfil the role, the system department consists with senior engineers who have had rich experience in multiple domains, being familiar with the costs and technical parameters of each department. Its opinions, reflecting a core intellectual accumulation of the firm, act the role of gatekeeper to direct the learning in critical direction and cost and time control. As an advisor to the project managers, it actually acts as a specialised standing agent in term of technological development for mobilising and directing the front-line engineers.

To summarise here, what we stress is not the formation of learning organising, such as the matrix-wise formation implemented by Group-B firms, although it was significant and made sense. What we stress here are the institutions that underpin the effective organisational mobilisation for learning, and integrate the creative individual learning for collective purpose. By investigating the learning organising of Group-B firms, we can say that the organisational mobilisation and learning integration would not automatically or easily happen within firms in DCs. Resource and human force investments, strategic intent, or even purposeful targets of learning are not sufficient for the emergence of organisational integration. Institutional arrangements are needed to incentivize members to learn on interactive platforms. First, front-line members need to be motivated with resource support. In Group-B firms, technical progresses in detail are not framed by administrative authority, external consultants or imported technical schemes directly, but rather by front-line engineers. To cope with the uncertainty underlying the development of complex systems, the interactions among different segments and departments are critical to control and push practical progresses in each domain. Then the inter-departmental platforms are at least as important as those based on specialised units are. For the intensiveness of developmental projects, the knowledge gatekeepers of specialised units have no intellectual ability and are not obliged to manipulate what exactly their subordinate members are learning or doing in detail. Rather, they just handle what kinds of tasks the subordinate members are carrying out and what kinds of challenges their members are confronted with. Therefore, their actual roles are as the tutors and coordinators of learning within their units, and the heads of technical services provided by their units to others. Since the creativities of knowledge reside on the basic organisational units for particular tasks, the application of resources at micro-level is entrusted to the basic units, rather than being exogenously determined. Meanwhile, the front-line practitioners should also be obliged to learn on the interactive platforms for collective purposes. The authority and resource allocation is employed to frame the organising of learning activities of participants, and to guild the technical integration. Otherwise, the development would be out of control despite feasibility and economical efficiency, and the interactions would not be bound as effective for resolving interrelated problems.

Certainly, the above entails a subtle balance between the organisational mobilisation and the technical integration for learning. As for this subtle point, Group-B firms developed their specific characteristic strategies and then routines during the organisational construction.

6.3.3 Knowledge database and supportive institutions

The system of knowledge accumulation, by which we referred to the facilities and institutions to collect, integrate and re-apply the knowledge that was created by members, worked significantly in Group-B firms. Firstly, it provided standing carriers of knowledge accumulation that helped the organisations steer away from relying on particular individuals. Negative effects caused by the departures of specific employees could be largely reduced. Secondly, it impelled the codification of tacit knowledge. In most cases, the construction of a knowledge accumulation system required members not only to submit their developmental blueprints and data but also to introduce or to explain the developmental process. For this purpose, members had to generate analysis reports and relevant documents, which intentionally or unintentionally codified their outcomes especially through collective discussion. Thirdly, it promoted the knowledge diffusion and re-innovation among organisational members, which fuelled the dynamics of knowledge accumulation as well. As colleagues and latecomer engineers could learn and apply the previous knowledge accumulated, knowledge trees could be cultivated dynamically through the development of the understandings and re-innovation of organisational members. It was also significantly helpful for the learning of new-coming members in that it provided prolific references. Fourthly, it contributed to knowledge flowing and cooperation beyond departmental boundaries and the time and locus limitation. With regulative permission, engineers were able to access knowledge accumulated by relevant units, which helped to promote the SECI process of knowledge conversion within firms. Therefore, in Group-B firms, knowledge databases became the physical platforms for the work and communication of engineers. Fifth, knowledge accumulation process was meanwhile a process of knowledge promotion and learning. To combine information from different organisational units led to not only new information but also new understanding (Huber, 1991, p101-102; Daft and Weick, 1984, p285).

In the following subsection, we stress the databases built by Group-B firms based on the practices of product and relevant technology development. It does not mean we neglect the knowledge accumulation of Group-B firms on processing technologies, but reflects our interest attracted by the difference by contrast with the Group-A firms.

6.3.3.1 Facilities for knowledge accumulation

The scale of knowledge matters a great deal with regard to the knowledge database. For instance, it is distinct for car door developers to have dozens of references as opposed to just one reference. Each reference presents the ideas and tactics of its original authors corresponding to different design requirements. Thus, the ideal situation for a database is obtaining numberless references, so that its applicants can achieve new designs by simply combining and improving previous designs if they can decipher the requirements they meet. In this sense, building a robust knowledge database is a strategic target for firms, which must be based on an accumulative process.

The widespread of digital tools facilitates the codification of knowledge accumulation, and helps it go beyond the time and locus limitation. Many Group-B firms had stressed digitalisation of knowledge accumulation from their early years on, but the situations among them were divergent. Geely and HaFei presented the two extremes in their inceptive stages. HaFei had begun to build up its strength in digitalised product development since 1983 in the airplane domain; and as we said, it later transferred relevant capabilities from its airplane division to its auto division. As for Geely, it was backward in making use of digital design tools in its inceptive phase, although it did not mean Geely had not taken good care of its technical documents. For the development of its first car model, Geely's engineers could only employ hand-drawing which resulted in the asymmetry between the designs of left and right car doors, which was discovered by its in-house engineers only after they got equipped with digital mapping technologies. Only after 2002, did Geely transfer its CAD department from the motorcycle firm to the car-making firm, which started the latter in constructing a comprehensive digital knowledge database.

In general, since developing their respective 2nd generation products, all Group-B firms had already established comprehensive knowledge databases based on digital technologies. Features of their knowledge accumulating systems could be generalised as follows:

Firstly, not only were the data of well-package designs included in the knowledge database of Group-B firms, but the analytical reports and explanative documents were included as well. In other words, knowledge databases were much more than just the pure archives of final blueprints.

Even exhibited as final designs, much embedded knowledge was still complicated or tacit, and could be demonstrated well only with necessary analyses and explanation. For example, developers in the telecom-equipment sector might be unable to present their ideas clearly by using pure programming lines, although they added non-executable lines as short illustrations in the programs. Especially programs could contain code lines in huge number, which contributed to the complexities to decipher the relevant knowledge, and added to the difficulties that new-coming members had in learning. The technical linkages within product systems also introduced complexity. In the car-making sector, the development of the brake subsystem was closely connected to the analyses of the dynamics of entire vehicle, the road conditions and even the possible weight loads and distribution. Without relevant supportive explanations and analyses, colleagues and new-coming members would have difficulties to understand why corresponding designs were selected while others were not.

So, writing up experiences, explaining ideas and analysing technical choices were important for the communications based on knowledge databases. Especially within the Group-B telecom-equipment firms, "*turning over the documents (copies)*" was jargon to describe that their jobs had been done and they were delivering the task to the next step.

By contrast, among Group-A firms, there was no case in which MNCs provided their productive Sino-foreign JVs or Chinese SOE partners with the analytical reports or explanatory documents as supporting materials for their blueprints sold. Even worse, they would cut off the so-called "unnecessary" remarks from the original blueprints, as they did not want to provide information for their Chinese partners to use potentially in reverse learning.

Secondly, knowledge databases in Group-B firms did not just include the data or documents about existing models or procedures, but also those about the trial and failed attempts. The data about trials and failures disclosed the tactics and manoeuvres employed by developers when they addressed particular technical and economic dimensions. Colleagues and latecomers could learn from them about not only the contrasts to successful experience but also other considerations, analyses, audits and decision-making processes, which helped to put them into the real complex of development under those circumstances.

Thirdly, data originating from mapping and analysing the products of competitors were recorded in their databases. In fact, this was an important way of Group-B firms to enhance the amount of data and to construct their databases to realise the economy of knowledge scale.

Fourthly, knowledge databases were difficult to purchase on the external market. Since knowledge databases were broadly regarded as the core intellectual property of firms in product-oriented industries, it was difficult to buy such databases unless new indigenous firms could merge the target firms as whole. Some specialised consultant firms did offer their databases for sale. Nevertheless, with very few exceptions, what they could offer were data obtained through mapping existing products on the market, for estimated price at several million RMB per model in general (retail, data from 2006). If indigenous firms had already built up their appropriate in-house product development teams, to generate such data were only normal jobs consuming resources, human forces and time. Furthermore, data sold by them were without relevant analyses or explanation, since the information providers did not really experience the developmental process. The usefulness of the data they provided was positive but limited to the building of in-house knowledge accumulation systems of Group-B firms.

Fifthly, the formation of knowledge databases was dissimilar among Group-B firms; but no matter what kind of formation they used, they all realise the effective collection and re-application of knowledge all over the general range of their organisations. For Group-B car-making firms, general knowledge databases had been built up across different developmental units. With permissions, engineers could access the knowledge databases in relevant domains in general. In the telecom-equipment sector, since this industry had already been highly modularised, the departmental knowledge databases were more active than the general database, while the project management department obtained all developing data and documents in theory. Since the computer network of firms could link departmental databases easily, their knowledge databases were also accessible for in-house engineers in general under a set of institutional arrangements.

6.3.3.2 Arrangements to promote knowledge accumulation

Certainly, knowledge would not converge at a particular locus automatically. In Group-B firms, a series of institutional arrangements have been set up to regulate the contents and time-schedules of accumulation and to facilitate the processes.

In Group-B firms, to archive data and documents was not an option for organisational members, instead was a compulsive requirement. It was embodied as binding regulations, and was presented with detailed schedules in project plans associated with resource allocation.

As for developmental projects, the procedures of “*inspection*” at the end of each step and the procedures of “*inspecting and confirming*” following each stage were meaningful in both technology and governance (see subsection 5.2.3 in Chapter 5). The handover of relevant data and documents was necessary to complete the “*inspection*” or “*inspecting and confirming*” procedure, which meant the data for the corresponding step had been frozen and passed over to the next step. Unless the data were officially activated again by higher authority, relevant data were not allowed to be changed as valid versions in the project. Without the “*inspection*” or “*inspecting and confirming*” procedures being completed, the project could not proceed, and further resource allocation for subsequent procedures would not be made.

By comparison, in Group-A firms, since the systemic products were not locally developed in China, the relevant data and documents about the development processes certainly were not presented to local Chinese engineers. Regarding the model localisation projects, foreign sides controlled the “*inspecting and confirming*” procedures. Thereby, the headquarters of foreign sides controlled the comprehensive data accumulation while the Chinese sides only had the data of adjustment parts and the process data under their control.

In Group-B firms, besides the accumulation based on product and technology development projects, they also allocated funds for programs to promote knowledge accumulation.

Firstly, the standardisation of technological experience accumulated was stressed. Engineers were mobilised to standardise the experience that they had to generalise typical parameters for designs, and consequently to generalise typical designs scheme. It could promote the efficiency, shorten the development cycles and increase the interchangeable rate of components among product models and platforms. Meanwhile, it was also a process of knowledge integration and re-innovation.

For example, within the "instruments and meters development group" of Chery which was a common basic unit of Chery's R&D force, engineers summarised 47 key parameters for the design of consoles, and further, they sorted out a series of development solutions in responding to typical technical requirements. The outcomes were published as the departmental development manual. Then colleagues and new-coming members could learn from and apply the standard experience. In order to incentivize engineers in doing so, awards were offered.

Secondly, the analyses of failure were stressed. The FEMA (Failure Mode and Effects Analysis) was developed by studying historical failures, and used to avoid failures beforehand, including D(evelopment)-FEMA and P(rocessing)-FEMA. Even though FEMA handbooks could be purchased on the market, its development was still highly firm specific because the sources of failure might be firm specific. Sometimes even with the same term, modes of failure might be different since failures were deeply embedded in organisational processes. For instance, the oversized clearance between the car-door and the bodywork could originate from the stamping die providers, from the operations of the assembly line, from the inexperienced bodywork designers, or from the weakness of material engineering. As well, the patterns of identifying and coping with failures were also firm specific. Whether the oversized clearance problem should be attributed to the die suppliers, to the processing line, to the bodywork development unit, to the material research unit, or whether it should be investigated thorough the involved organisational units, was a question of governance more than one of pure technology or engineering.

Thus, the building of FEMA in-house was a continuous re-consideration and self-improvement of the technological development system of firms, and required thorough study entailing all involved units. In Group-B firms, inter-departmental teams were set up for developing FEMA. Interviews and investigations were arranged. Conferences were held in which relevant units were all engaged to discuss existing development patterns and potential weaknesses. If the situations were too complicated, trials could be implemented to imitate the previous process. Even special departments were set up to carry out continuous innovation and failure analysis, such as the "Commercial Improvement Department" in Chery.

6.4 Analysis: contrasts between the two groups of firms

In this chapter, we have analysed the organisational learning patterns of these two groups of firms. A summary is made here to present the comparisons directly.

6.4.1 Authority over resource allocation

There is a distinguishable difference on the authority over strategic resource allocation between the Group-A and Group-B firms. The difference can be demonstrated by the composition of backgrounds of their top committee members. In Group-A firms, the engineering force for the development of product and product technology was marginalised on top committees; instead, people from the production lines and other divisions dominate the strategic resource allocation. The marginalisation of product development personnel in the power structure partly resulted from the legacy of industrial system in the former central planning economy. The comparative disadvantage of indigenous R&D personnel than foreign experts, the emphasis on manufacturing localisation and the neglect of indigenous platforms also enhanced such a situation.

By contrast, the product development force played a leading role in decision-making of strategic resource allocation in Group-B firms. The path-dependency affords the experts of product development a comparatively superior voice within Group-B firms. Furthermore, Group-B firms continue pursuing product-oriented competition, which has the R&D force at the locus of the development scheme under uncertainty.

6.4.2 Organisational mobilisation and learning integration

Regarding the arrangements of them to mobilise organisational members and to integrate learning for collective and purposeful targets, there are also recognisable differences between them.

As for Group-A firms, there were barriers opposing the organisational mobilisation and learning integration. The process of production localisation was separated into professional segments and carried out by specialised external co-operators and internal units. Such a scheming process was totally top-down associated with the well-developed imported blueprints. Then except for the task layout at inceptive stage, there was no practical need for participants to be mobilised and to generate any further understanding to cope with uncertainties related to product systems and in-depth linkages between different segments. Consequently, there was no need to maintain the cross-boundary communication among front-line engineers, and certainly, there was no arrangement that enabled the R&D force to mobilise the resources effectively from other participant units. As for each professional segment, knowledge gatekeepers were set to stress the productivity of learning upon imported blueprints and other assistant guides. The contents of learning were supervised, as heterogeneous thoughts about product systems were regarded as unproductive, which ruined the foundation of organisational mobilisation for integrative learning under uncertainty.

As to the in-house R&D forces of Group-A firms, they also were fuelled with resources. However, there was no normalised mechanism to connect their R&D activities with the learning activities placed on the centre stage of Group-A firms, i.e. the practices of production localisation. As well, there was no regular mechanism for the R&D forces to activate organisational members of relevant departmental units to generate integrative thinking grounded on or beyond the imported technological data. Without the support of higher-order organising principals, functional knowledge would not come together by new recipes (Kogut and Zander, 1992). Even within the R&D forces, resources were allocated based on top-down and branch-based arrangement, which organisationally blocks the horizontal communications for technical integration.

By comparison with the highly professional and rigid systems of learning in Group-A firms, the technological learning activities of Group-B firms were built on cross-boundary inter-departmental platforms in addition to the specialised developmental activities in professional departments.

In addition to the matrix-wise relations between the product development teams and functional departments, Group-B firms developed a series of institutional arrangements to encourage inter-departmental interactions and learning. Many critical activities and controls of developmental progresses were tied to the cross-boundary inter-departmental platforms. To underlie such an arrangement, in addition to the fixed funds for professional departments, the allocations of strategic resources were entrusted to project teams, which were formed by representative engineers from multiple relevant departments. Then being independent in budget from any specialised department, the project teams could allocate the resources on hand according to the needs raised by practical developmental processes. So the concrete technological progresses were achieved by the front-line basic units with resource allocated based on the logics deriving from their collective learning process; their behaviours were not restricted by any exogenous technological scheme. During the developmental process, higher authorities were arranged to frame the organisational coordination of learning, particularly those to realise coordination across different intra-organisation boundaries.

6.4.3 Knowledge accumulation systems

In general, Group-A firms had not built up comprehensive knowledge databases. The actions of collecting intellectual outcomes within their organisations were executed as response to the top-down authority. The codified experiences were collected from the front lines, but the process was framed by the top-down given frameworks, namely by the knowledge gatekeepers and underlying institutional arrangements. As the primary developmental task for practitioners was to imitate imported models, the major intellectual accumulation was presented as the experience of best practices of manufacturing operations. Since the major embodiments of intellectual accumulations (i.e. the operational handbooks or manuals) were updated only by years in most cases, such a system rooted out the possibility for organisational members to interact with the collective knowledge accumulation dynamically, and contributed little to the knowledge diffusion across different units in real time. As to the in-house R&D forces, as they were marginalised in Group-A firms, the knowledge accumulated from their practices as databases was also isolated with the experience based on production localisation. Certainly, since they seldom had resources authorised to implement development of systemic product and complex product technology, and since they were unable to obtain full sets of blueprints from foreign partners, their knowledge accumulations was obviously limited.

We cannot attribute the disadvantage of Group-A firms in building comprehensive knowledge databases to their resources, as we ever compared their resources advantage over those of Group-B firms. In theory, there was also no external constraint to stop them from developing in-house knowledge databases. At least, Group-A firms could expand their knowledge pools by studying existing competitive products[113]. However, to invest in knowledge accumulation was “expensive” both in terms of resource consuming and in terms of authority of governance. Their stagnancy of knowledge database was embedded in the underlying organisational institutions and resource allocations as we mentioned above.

By contrast, Group-B firms imposed the regulations for experience summary and submission on the procedures of project progress, which was associated with the allocation of relevant resources. Such institutions mobilised organisational members to participate in the collective knowledge accumulation along with developmental activities their implement. Besides, Group-B firms also implemented a series of special projects to promote the quantity and quality of knowledge accumulation, including standardising the experience, systemically analysing the failures, etc., which also required efforts of members to achieve in-depth knowledge conversion, and to explore learning integration.

Since the knowledge databases of Group-B firms were generally accessible to their in-house engineers in relevant domains, the databases worked as locus of knowledge conversion, diffusion and re-innovation, and even became important physical parts of product development platforms for the implement of learning and cooperative activities.

6.5 Summary: comparison of organisational learning systems

In these two chapters, we explore the organisational black-boxes of these two groups of firms. We cannot affirm that important features relating to technological learning of firms have all been

[113] Certainly, without practical considerations for industrialisation and commercialisation, the accumulation of knowledge about existing products cannot lead to significant growths of in-house technological capabilities. Otherwise, specialised consultant firms should have already become excellent integrative product providers.

covered. At least the features in question are closely pertinent to the learning patterns of firms. The two groups of firms demonstrated a series of differences, although most of them could not be simply measured by quantitative methods.

Certainly, these differences did not occur in an isolated manner. They were deeply interlinked with each other, and are connected with their differences of activities that worked as the foundation for the "organisation-technology-product" platform of firms regarding capability-building. They were as well relevant to the dissimilar evolution of strategic intent. In line with the gradual shift of strategic intent, Group-A firms had their knowledge search localised because the development of "proximate" technologies only did not oblige them to change their recipes for organising research (Kogut and Zander, 1992, p392). By contrast, the strategic intent of Group-B firms directed their resource allocation, learning organisation and knowledge accumulation.

Some may argue that the differences between Group-A and Group-B firms just reflected the dissimilar inclinations between incumbents and new entrants. However, considering their macro contexts, both Group-A firms and Group-B firms were latecomers in terms of technological capability by comparison with international frontiers. In particular, Group-A firms had not had historical advantages of technological capabilities as legacies for their rigidity, even if we take core rigidity as the other side of the coin of core capability (Leonard-Barton, 1992). In other words, Group-A firms were becoming rigid as regards building new technological capability, not because of the negative symbiotic legacies of being strong, but because of the inertia of being weak. Consider the fact that for stretching their production capacities (such as building up new JVs repeatedly) Group-A firms were continually transforming their organisations during a long period, which suggested their flexibility of organisation in a pure sense. Meanwhile, it is also unreasonable to argue that the weakness in technological capability building was brought about by *specific* organisational rigidities when firms focused on other strengths, unless we admitted that it was in general very difficult for firms to build ambidextrous organisations good at both production capacity and technological capability simultaneously. However, even without accounting for the international giants, the success of Group-B firms also has rejected this hypothesis.

After acknowledging the above differences of organisational systems between these two groups of firms, we still have to verify the significance of these differences. Firstly, we must prove that the patterns of Group-B firms were effective for capability-building and commercial prosperity. This point has been verified by the successes of Group-B firms. Secondly, we shall claim that the organisational features of Group-B firms related to these differences were directly associated with their performances ion technological learning. This analysis is in the next chapter.

Chapter 7. Process: knowledge creation and organisational learning systems

7.1 Introduction

This chapter aims to identify whether the organisational features of Group-B firms related to the differences from Group-A firms highlighted in the last two chapters were significant for the processes of technological learning of Group-B firms.

In this chapter, we stress the processes through which Group-B firms searched for, generated and accumulated new knowledge. This does not mean we neglect the significance of "learning by doing" which brings about the refinement of skill and the incremental increase of knowledge. Rather, we just aim to highlight the dynamic processes of DC firms in developing in-house "new-new" knowledge to undertake sustainable catching-up.

In fact, the special interest in new categories of knowledge comes from reconsidering classical stepwise studies of technological learning in DCs. In explaining the technological paths or trajectories taken by catching-up firms, resource-based factors are usually taken into account, including the intensiveness of R&D expenditures, the accumulation of human resources, the prices manipulated by government, etc. These can help explain the supply of technological learning in particular stages, but can hardly reveal the indigenous dynamics of latecomers to leap from one stage to another in pursuit of capabilities of a higher category. In this sense, the position of latecomer firms in generating knowledge belonging to new categories should be at the heart of catching-up studies, no matter what trajectories the firms implement.

In this chapter, we mainly study the early phases of Group-B firms, from their inception up to about 10 years after they started developing their first systemic products. Our empirical analyses are organised in time sequence. Two issues are particularly stressed, namely the inceptive foundation of knowledge, and the major sources of knowledge search, generation and accumulation of Group-B firms.

7.2 Inception knowledge base

As Group-B firms were first-movers among indigenous technological and product integrators that grew up from the industrial foundations of transitional China, the knowledge and patterns of technological learning they created were likely to be new to both themselves and the entire domestic industrial community. Therefore, it is critical for us to disclose the sources of their inceptive knowledge, which acted as the core of a knowledge spiral.

We stylise the analyses of knowledge creation in Group-B firms as a "search-generation-accumulation" process, which definitely required resource investment. Relevant resources would not go together naturally nor readily coexist with some possible combinations, especially if the patterns were new to the practitioners. The effective transformation from resources to combinations and then to applications of resources requires Group-B firms to have effective organisational cores. As in the inceptive stage, the scales of organisations were all small, and the heroism of elites worked significantly to integrate the entire organisations. However, the organisational systems of Group-B firms demonstrated the following elements with their learning.

Firstly, the organisations must sustain their strategic intent regarding in-house technological capability building. As effective learning for catching-up purposes was new and entailed high uncertainties, the latecomer firms, or to be specific even their elite leaders, could not adequately scheme the practical learning schedules, patterns and directions, especially in the inceptive stages. The sustainable strategic intent rather than foreseeable plans activated the firms to explore continually the domains of uncertainty. In some cases, the strategic intent for long-term capability-building even reflected "unreasonable" investments in spite of any foreseeable plan[114]. Secondly, strategic resource allocation stressing technical and product development was also necessary. As for continually attracting excellent technical personnel, and re-integrating the intellectual assets on hand, these strategic activities could be completed only through practices of technical and product development. Thirdly, the mobilisation and integration involved was demanding; otherwise the learning implemented by Group-B firms would just simply throw the individuals with different competences together in ways that clearly made it impossible to generate any new knowledge dynamically.

As mentioned above, most Group-B firms started their businesses from comparatively simple, low-end products. They had to combine different modes of learning together (Kogut and Zander, 1992), such as learning through studying existing marketed products, and through recruiting and integrating personnel with complementary technical competences. However, if we stress the prominent sources of knowledge in their inceptive stages, the situations were somewhat different between the car-making and the telecom-equipment sectors. In the car-making sector reverse engineering could provide useful information for the learning by Group-B firms. However, in the telecom-equipment sector, this method contributed very little, and firms relied more on integrating knowledge from multiple domestic sources after being inspired by the *HJD-04*.

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[114] For example, Huawei had started to accumulate and cultivate large number of young engineers from its inceptive stage on. For instance, REN required its Beijing Research Centre to expand the recruitment of new graduates in spite of worries about budgets and job assignments. REN claimed,"…even if new engineers were employed by us only to '*sieve the sand*' temporarily (in case Huawei had nothing well schemed for them to do once), we should still spare no efforts in recruiting engineering and technical personnel…" Following his directive, the Beijing centre expanded from 20 engineers in 1996 to over 1,000 engineers in 2000. Spare young engineers were assigned to study all kinds of communication protocols, which worked a significant role later during Huawei's transition from narrow-band to wide-band communication systems, and from a follower of product strategy to an innovator of new products (e.g. its soft-switch technology largely originated from the Beijing centre), which began in the late 1990s [according to the interview with Che HaiPing (2003)]

7.2.1 Car manufacturing sector

In the car-making sector, reverse engineering of products has been taken as a popular method to generate useful information for product development by the entire global automobile community. Group-B firms also implemented this method. However, this did not mean that early products of Group-B firms were based on copying or simply imitating competitive products. Existing products were just drawn in to be studied as references for Group-B firms in developing their own designs (see subsection 5.3.2 in Chapter 5). This method did help remarkably when Group-B firms had not accumulated sufficient scales of their knowledge databases.

Figure 7.1 A pattern of re-innovation based on studying referential product models

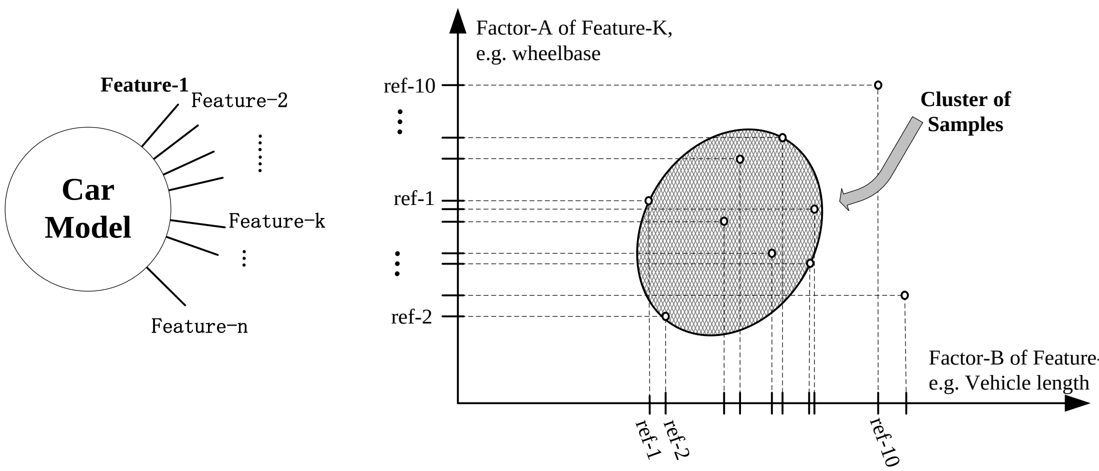

Figure 7.1 exhibits the pattern of re-innovation based on studying referential models. Firms study existing products that would compete with their developmental target as references. For example, they collect all A-level sedan models specialised for family use if they want to launch one on fheir own in this market segment. Features of the product systems are generalised and further studied. For each feature, a series of prominent factors are highlighted. For example, for the feature of “inner space of car body”, engineers would include such factors as the “wheelbase”, the “vehicle length”, and so on. Data of referential car models for each factor are obtained by reverse engineering. Usually developers would group factors into couples or triples, and place each factor into multiplex groups consistent with logically relevant factors. Clusters that consist of dense points of references are identified by projecting the data of references onto the 2- or 3-dimension coordinate systems. Meanwhile, developers pursue their firm-specific analytical procedures based on their idiosyncratic technical tendencies, in-house capabilities, and capabilities of their supply chain. Then the distributions of referential clusters are employed by developers to help determine the corresponding factors of in-house product design.

If we regard the real data of existing products as the embodiments of knowledge of their original developers, this method enables latecomers to extract, translate and interpret the relevant information by reverse engineering, and give it meaning (Daft and Weick, 1984) based on their own understandings. The data are integrated with the knowledge that in-house engineers have already obtained to generate new in-built understandings of the product system (Kogut and Zander, 1992). Besides, as a practical strategy for product development, to locate the technological dimensions of their designs within the clusters of references can guarantee that latecomers stay away from gross errors of design, which thereby bring time and cost savings. Certainly, with the interpreted data, it does not mean that latecomer developers could think or act as original experienced developers of studied products did. Dynamically, the effects of learning depend on the in-built knowledge foundation and the *services* generated by the in-house forces collectively.

Therefore, the implementation of this method is highly firm-specific. If latecomer firms rely on this method in generating product configuration, it directs firms to be with the following strategy of product development. In fact, most Group-B firms in either sector experienced such a phase in their early years of product following. As for extreme cases, if the latecomer firms have only very weak in-house technological capabilities, and study only a few references, the result of development would likely come out as the simple imitation of target models, as some of these cases had been criticized or even sued by international competitors in the car-making sector. However, the Group-B firms in our study had not fallen into that category of extreme cases. On the contrary, along with the growth of financial capacities and technological capabilities, Group-B firms continually promoted large amounts of referential models, and refined their analytical techniques. For example, in the database of Chery for windscreen wipers, the referential models had reached over six hundred in number (data from 2006). However, the importance of the re-innovation method had been demoted from a major type of product configuration to an assistant tool, as in-house engineers had formed, to boost their own understanding of product and technical systems. Indeed, Group-B firms have turned to obverse product development patterns after they completed the development of their second-generation products.

Certainly, re-innovation was not the only theme of the developmental activities of Group-B firms in their inceptive stages. In the subsections below, we analyse the detailed processes of Group-B firms in two dimensions – their organising of teams and their activities – to establish the inceptive knowledge base, and aim to highlight the relationships between them.

7.2.1.1 Inceptive knowledge base of Chery

Chery, when it was established as an entity, was an outsider to the previous administration of the automobile industry by the central planners. We have already elaborated its earliest organisational configuration in the Subsection 6.3.2.1.

Chery originated in the "951" project of Anhui Province that was started in 1996. In order to avoid offending the industrial regulator, it was registered as the "*Preparatory Office of Anhui Auto Parts Industrial Corporation*" and concealed its car development activities at the beginning. At that time, Chery invested all self-owned assets and loans into the new product development projects and the construction of production facilities for these projects. In order to save resource for product development, during developing its first car model, founding members even worked and lived in timber sheds without constructing the "unnecessary" buildings.

The earliest project of Chery was to buy and move back an old manufacturing line for Ford *CVH* engines from Bridgend, Wales, UK[115], and to develop two optimised engine model based on *CVH*. The outcomes, namely the *CAC478* and *CAC480* engines, were medium product innovations that relied on the experience of former FAW engine experts.

Meanwhile, the first car model of Chery, namely the *Fulwin*, was started to develop. During the course of development, Chery's engineers had studied a series of competitive models, such as the *Palio* of Fiat and the *Polo* of Volkswagen. However, as we said, when the development of supply chain met difficulties, *Fulwin* was adjusted by targeting the 1991 version of *Toledo* (SEAT). Indeed, Chery had been familiar to the *Toledo* system before[116], and had option to buy a batch of cheap machines uninstalled from a *Toledo* production line, which were held by a Taiwanese firm. After the launch of *Fulwin*, Chery was charged by Volkswagen. However, the charge was for the violation of the "*VW*" brand that was discovered on some chassis assemblies of some *Fulwin* sets[117], not for the violation of product design. It reflected that in essence the re-innovation process of *Fulwin* model development was not simple imitation or copying.

The high price quality brought *Fulwin* success quickly. As a family-use economic sedan, it was priced at only 1/2 to 2/3 of the prices of the "*Old Three*" models[118], and ranked the No. 9 on the Chinese market of 2001 (the first year it got permission to sell nationwide) in terms of sales of individual car models. It contributed significantly to the change in the Chinese market structure.

For the other first-generation car models of Chery, i.e. *QQ (S11)*, *Eastar* (*B11*) and *Cowin* (*A14*),

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[115] This line, which was priced at 25 million USD, was bought as a preparation of new car development plans of Chery. Due to the bad performances of the engineering force of the dealer, Chery's local engineers took over the second stage instalment of this line.

[116] From the end of 1996 on, Chery began to contact SEAT for the purpose to import technologies for locally independent production. Several negotiations had been arranged between the involved two sides, but came out with no official agreement.

[117] It was caused by the negligence of Tower Automotive (U.S.), a supplier for Volkswagen's *Jetta* model and Chery's *Fulwin* model. For the charge of Volkswagen, Chery had to stop import from Tower, and turned to rely on in-house technical and engineering force. And its in-house force did manipulate in relevant engineering and production of the corresponding chassis assemblies. In 2003, Chery and Tower Automotive began to build up a productive JV in Wuhu City and carried out close co-operation in chassis development and manufacturing

[118] In 2001, the prices for the basic setting version of *FuKang-1998*, *Jetta-1998* and *Santana-2000* were 133000, 155000 and 175000 RMB/set, while Fulwin was priced only at 88000 RMB/set only.

the re-innovation pattern was also an important method employed by developers. However, the amount of referential models of reverse engineering and the efforts of observe-engineering continuously increased. Therefore, when GM claimed Chery's *QQ* violated its *Spark* model (also the *Matiz* of Daewoo) in design, Chery was able to present 24 patents it had obtained related to the designs of *QQ*.

This change originated from the growth of Chery's in-house capabilities, which firstly came from the expansion of its organisation. For the expressional strategic intent and the success of *Fulwin*, Chery became an emerging power to attract domestic engineers with the same ambition. More than 100 former FAW engineers had taken part in Chery during the period of its 1st generation models development. A team from the R&D centre of DongFeng, which had experienced the model localisation in DongFeng-Citroën, participated in Chery as an affiliated design firm named Kaking. Kaking, by a series of trial and error, succeeded in taking over the tasks about systemic configuration and bodywork styling during this period. Then, the previous in-house product development team could turn to focus on product industrialisation. In short, every segment of Chery had been strengthened by participation of new personnel, and Chery mainly relied on competences carried by individual members. You can say Chery was practising a game of jigsaw puzzle, for which the institutions to activate organisational members and to integrate their learning, as depicted in Chapter 6, were definitely critical.

Secondly, the persistence of learning based on practical developmental projects worked importantly in integrating the existing competences of individuals and generating new knowledge. As we knew, for many critical parts of product and complex technology development, the in-house engineers had not obtained sufficient according competences, as limited by the general capabilities of domestic industrial community. For these tasks, developers had to take moderate risks by adventures, which was supported by the cohesive organisational culture and resource authorised. For example, as to the chassis, in-house engineers only had experience of developing truck chassis assemblies. As to the engine, in-house engineers only had experience of developing backward diesel engines. As to the systemic configuration and bodywork-styling, in-house engineers only had experience of model localisation which were carried out under the supervision by foreign experts in Group-A firms. As to the automotive electronics and internal accessories, in-house engineers had seldom experience of development. Regarding the adventures, the re-innovation pattern provided a critical platform for each professionalised unit to extend their knowledge base by studying competitive products and employing the combinative capabilities (Kogut and Zander, 1992). The practical developmental projects also provided a platform based for jigsaws to interact with each other, as the tacit knowledge carried by individuals could be revealed only through its application and through a series of mutual adjustments (Polanyi, 1966; Grant, 1996; Leonard-Barton, 1988, p265). Further, at the frontier of knowledge exploration within the national industrial community, the codification of knowledge was a highly organisation-specific phenomenon, and then the knowledge that had been codified in one organisation would not definitely was codified in another one. Then the close interaction, namely through the *communities-of-practice* on inter-department to platforms generate common structure and meaning for the transfer of each experience (Brown and Duguid, 1991), was the only way to make up necessary complementary tacit knowledge or even codified knowledge to facilitate the knowledge integration and further creation of new knowledge.

The growth of knowledge, which was represented as innovation (to the local organisations) in terms of product development, "*not only adapt to existing organisational and industrial arrangements, but they also transform the structure and practice of these environments*" (Van de Ven, 1986, p591). Chery's growth of in-house capabilities during this period was supported by its institutions in its inceptive stage as we depict in Chapter 6, which were fundamentally different from those its members had ever experienced in Group-A firms. However, as the depth of interaction growing, the organisational evolution was also required to co-evolve with the contents and patterns of knowledge creation.

7.2.1.2 Inceptive knowledge base of Geely

Geely shared many common grounds to Chery during their inceptive stages. Its strategic intent regarding indigenous product development attracted other members to participate in; the practical developmental projects that were implemented on the cross-boundary inter-departmental platforms provided the arena of competence integration among individuals.

However, there were also some special features in the case of Geely. Firstly, since Geely was severely short of finance, it employed a special contract responsibility system of factory building, by which some of the necessary workshops in its inceptive stage were invested by business partners that were not legally incorporated into the firm[119]. Thus, the authority of LI and his intimate circle worked critically in maintaining the organisational cohesion, especially in mobilising these units. Secondly, in the earliest years, Geely severely lacked experienced engineers. In 1997, only 7 engineers could be mobilised from its motorcycle division with backgrounds related to the development of comparatively complex products. Only 3 among them had experiences related to vehicle making, but were just for modified truck and jeep merely. Moreover, they had no digital development tools and relevant capabilities on hand.

For the very weak capability foundation for car-making, before developing its first product model

[119] This pattern was illegal by Chinese corporation law, but also reflected Geely's intent as to the indigenous product development.

for real industrialisation, Geely implemented three trial projects to establish a basic knowledge core which afterwards enabled Geely with basic components of absorptive capacity to interact with new-coming members, and to deal with the projects with real industrialisation aims. Geely started its first trial project in 1997, which was to disassemble two cars, and combined the bodywork of a *Benz-C280* with the chassis of a *RedFlag-CA7220*. This project yielded very basic knowledge of car systems and development for the team. The second trial project was to disassemble an *AnChi* (a mini-car produced domestically without regulative licence), with purpose to accumulate further knowledge about the product system and relevant lists of components, by which Geely began to establish its system of component management. By the terms we used for the re-innovation pattern, developers investigated the features and factors of the product system. In 1998, Geely started to imitate a car model, taking a *ZhongHua Bullet* (a domestically produced car without regulative licence) as benchmark. Besides the reverse engineering, combining their previous knowledge in the re-innovation pattern, Geely's team made a series of marginal design on this model, and even adjusted some technical weaknesses of the *ZhongHua Bullet* in the suspension. By manufacturing a small batch of the imitated cars, Geely's engineers got skilled in producing car products at comparative stable qualities.

The first model of Geely for real industrialisation, namely the *HQ* series, was started in 1998. The developers studied several car models as references, such as the *FuKang* of DongFeng, the *Lancer* of Mitsubishi, the *Alto* of Suzuki, the *RedFlag* of FAW, and the *C280* of Benz. However, similar to Chery's case of *Fulwin*, Geely's in-house developer finally took *XiaLi* as the target model in order to adopt the engine and some chassis assemblies from the existing domestic supply chains of *XiaLi*. Besides, the *ZhongHua Bullet* model that Geely ever in-depth studied had many similarities to the *XiaLi*; and by contrast with other references, *XiaLi* and *Aldo* were much simpler in structure, which was in line with Geely's expectation regarding the first attempt of industrialisation. However, we cannot simply say the *HQ* was developed by simply imitating the *XiaLi*, considering the technical features with obvious differences, such as the car height. Ironically, many features of the bodywork of *HQ*, especially in the front and rear faces, car doors and lateral assemblies, tried to follow the classical features of *Benz*, although we must say that these "luxury" styling features looked very unsuitable on an economic compact car model.

The participation of new experienced engineers supported Geely much in developing the *HQ* into an industrialised model. Since 1998, a series of experts from SOES who were dissatisfied with the TMFT policy joined this new firm. Some policy-makers that had dissimilar opinion to the mainstream also unofficially encouraged engineers they personally knew to come and help Geely. Besides, from 2001, Geely started to benefit from the graduates from its own education division (Geely built up an education system as its second largest business since 1998, partly for its suffering from the lack of R&D personnel in inceptive stage).

After Geely had proven its potential and attempts with the *HQ* series, a larger tide of local experts came to join Geely since 2002. Among these new-coming members, there included the former chief engineer of Nanjing-Fiat, the former vice directors of FAW's R&D centre, the former CEO of FAW-Daewoo, the vice president of Daewoo (Korea), and so on.

Similar to that of Chery, the integration of these jigsaws and the further new knowledge creation in Geely were realised through a series of practical developmental projects. Different models were developed based on the *HQ* product platform, such as for bodywork-styling favouring female taste (*MR series*), for lager inner space (*HQ-7131*), and for flexible uses (*HQ-SRV*). Another product platform, namely the *Maple* series, was developed by taking the *FuKang* of DongFeng-Citroën as the target model of some chassis assemblies. Regarding the critical technologies, Geely put forward a 4-cylinder engine model and its own EPS system in 2002. The basic force for the development of this engine model was a team having experience in diesel engine development only (came from the Shanghai Diesel Engine). However, being integrated into the new knowledge system and being associated with relevant units, this team succeeded in transferring their capabilities into the new domain.

The accumulation of knowledge cultivated new changes. Geely's knowledge database had been transferred into a digital framework since 2001, and developed into a basic economic scale of references. Meanwhile, the routines for cross-boundary inter-departmental interaction had been in-built. Thus, the growing in-house forces called for adventures about new patterns of learning organising, and new technological implementation. From 2002, Geely developed a sports-car model and launched it in 2004. Its output, namely *Mybo*, was Geely's first obverse engineering project of product development, although some chassis assemblies of *HQ* series were still adopted in order to preserve high interchangeable rate of components, which presented the capability growth of Geely in the previous years.

7.2.1.3 Inceptive knowledge base of HaFei

By compared with Chery and Geely, HaFei was confronted with two special conditions in its inceptive stage. Firstly, HaFei was a quasi-military SOE, which disabled it to hire people from the external market; rather, it had to rely on internal training and the human resource system of the governmental aviation industry. Secondly, HaFei Auto was originated from a group of technical experts from HaFei Aircraft. The development of aircraft was very much different from the development of automobile. Therefore, HaFei Auto had to transform the in-house expertise to meet the requirements of automobile development.

In 1983, the national automobile industrial administration decided to permit HaFei, ChangAn and ChangHe to enter the sector of mini-bus making which was in response to the appeal of the MOAI

(Ministry of Aviation Industry) and the Ministry of Weapon Industry to offer these military background SOEs an opportunity to make a living and to feed their appointed major business. Therefore, from the day it was born, HaFei Auto was confronted with tough pressures to survive and to feed its aircraft-making division[120], which through the effective management engendered organisational cohesion, or something we can refer to comradely fellowship under crisis to support the appointed task and keep every member on board[121]. Besides, the founding members brought about the technology-oriented gene that, associated with the sense of honour for being a military background firm, grew up into the tradition of stressing indigenous capability building.

HaFei started the automobile development from 1983. At that time, in order to help the three SOEs, the government planned to import the blueprints of *SK90* from Suzuki; however, after obtaining the approval of mini-bus making, the three SOEs could not wait but started to study the *SK90* on their own. Data were generated by precisely mapping. Besides, HaFei made a series of changes of design, including the vehicle length and wheelbase, the height and width, the suspension system and external accessories, and designed the new bodywork to develop the *SK90* it studied from a mini-bus into a pickup named *WJ-120*.

The outcome was good, but in the process HaFei met a series of difficulties, related to the pattern its engineers implemented to carry out development. Firstly, the developers did not recognise that as products for mass production the automobiles should be developed with stress of quality consistence. The precisions of component designs were always over-stressed, since developers got used to the “higher the precision, better the performance” thought of aircraft making. The engineers ever adapted the screws for aircrafts in the design of pickup because the screws were excellent regarding the precision (which could realise air sealing). They ever adopted the engineering plastics as stamping dies for some outer covering pieces, because they got accustomed to improve the designs consistently to promote the quality of design, for which the engineering plastics enabled them to adjust the dies but required much investment in subsequent refine of the products. As an extreme case, the parameters of gears for the transmission assemblies in *WJ-120* were different from the parameters in the mini-bus model of ChangAn although they did map the same model (*SK90*). It was because the abraded gears in the benchmark *SK90* sets

[120] The financial pressure was huge. Take the situation in 2002 as example, the total revenue for HaFei was 7 billion RMB, among which 6.5 billion was from HaFei Auto. HaFei Auto had to support the HaFei Aircraft financially. In fact without mentioning the high expenditure in physical cost of the aircraft-making division, HaFei Aircraft engaged 12,000 employees out of the total 18,000 of HaFei. Including all share-holding service agencies spun off from the HaFei Group, there were in total 60,000 people for 6,000 employees of HaFei Auto to feed. And it explains why in building its new manufacturing plant for *Lubo* (HaFei’s first car model) in 2002, HaFei only had 0.9 billion RMB available, which was its total financial accumulation in the past over 19 years.

[121] In fact, during 1984-2005, only one member of HaFei was fired, and it was for his criminal reason. We should note that, as contexts, during the great lay-off in the late 1990s for the reformation of SOEs in China, it is broadly believed that about 22-30 million industrial workers had got laid-off. The Northeast China, where HaFei is exactly located in, was the harder-hit area since it was the traditional heavy industrial base of China. So as a SOE, HaFei’s achievement could be even regarded as a miracle.

were precisely measure by the developers of HaFei. Finally HaFei had to invest a gear factory by itself since the gears of *WJ-120* were not interchangeable to those of ChangAn's, and was not even in line with any in the Chinese national industrial standard.

Secondly, engineers had not changed their cognition about the producer-customer relationship. They were attracted more by the performance rather than the demands of customers. They ever presented 8 different prototypes as the final industrialised models of *WJ-120* to the decision-makers, and claimed that each prototype was with technical specialities and should be developed as "customised" models. However, none of the feature derived from real market demands. In delivering the *WJ-120* products to dealers, they even included a "non-achievement" list as they did in the aircraft-making industry[122]; and for different batches of *WJ-120*, the contents of the "non-achievement" lists were even different from each other!

Thirdly, the labour division for the aircraft development in HaFei was based on the technologies implemented, such as the sheet-metal shaping, rubber manufacturing, and magnetic material-relevant technology. By contrast, the professionalization in the automobile development for mass market was according to the processing procedures and relevant developmental objects, such as the bodywork stamping, bodywork welding, bodywork painting and chassis assembling. They followed different logics, and HaFei had to invest a lot of cost in management to organise the development and production of *WJ-120*.

The dull sales for the first batch of *WJ-120* product compelled HaFei to re-consider its patterns of technological learning. A series of efforts was implemented during 1985-1992 with several practical projects, including the development of a two-row-seater *WJ-120* pickup during 1987-1988, the development of *SHJ* series mini-bus during 1986-1992, and the development of supply chains. During this process, engineers of HaFei started to implement market research, changed their previous developmental habits, adopted the re-innovation pattern, and realise the building and transformation of specialised units. For the sake of brevity, we pass over most details, but focus on what especially HaFei had done in order to build up a new organisational learning system by contrast with the Chery and Geely cases.

In order to change the minds of its engineers, HaFei organised their engineers to visit domestic manufacturing firms. The visiting targets included not only large SOEs but also local small- and medium-sized township firms as the latter presented good performance in quickly responding to market demands. Some leading engineers were sent to visit Suzuki and Mitsubishi.

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[122] This meant that for non-essential technical features, if providers could not realise them as expected, they could list them out and inform customers. Conventionally in the aircraft industry, customers would not refuse to accept the product if they could get an appropriate price reduction or they would allow a time extension for the producer. It was acceptable based on the essence that aircraft-making was a customised industry in many cases.

Internally, HaFei highlighted the tradition inherited from the central planning era (refer to the "*AnGang Constitution*" in Chapter 8) and held regular on-site conferences at workshops to discuss technical and managerial questions. Engineers of all units were called upon to join in conferences at firm level at the beginning. Later, such conferences were developed as regular arrangements at department and workshop level. In these conferences, the "criticism and self-criticism (PiPing Yu ZiWo PiPing)", as a legacy of the CCP (Chinese Communist Party) for decades, were implemented among participants as a principle for improvements. Managers and leading engineers led the way of criticism and self-criticism first, followed by other common engineers and workers. Topics covered a range of managerial reform issues and technical problems. Standardisation and robustness of development methods were major targets for them to achieve collectively. With a traditional and quasi-political atmosphere, the regular inter-department conferences and the "criticism and self-criticism" produced a platform for this organisation under pressure to facilitate disruptive organisational changes. Information was shared, transmitted bottom-up and transmitted horizontally across boundaries of different units.

The milestone of HaFei's organisational transformation happened in 1991. In order to build up the production lines for the *SHJ* series (50,000 set/year), HaFei mobilised most of its engineers from all departments to take part in this project, including scheming the plants, developing or outsourcing the machines, constructing the production lines, and so on. The reason for doing so was to save cost under the tight financial situation[123], for which HaFei had to minimize the outsourcing, and develop a number of machines in-house. Besides, decision-makers also considered it an important chance to promote the cross-boundary mutual learning. The organisational structure of specialised units was temporally knocked down, and new structure specialised in plant construction was set up. R&D engineers were also deeply involved in developing, testing and adjusting the manufacturing equipment. In this way, the engineers got deep mutual understanding of the technical criteria and guidelines of each other.

These efforts yielded good performances. Engineers gradually mastered relevant development tools and organisational methods for cross-boundary inter-departmental cooperation. Particularly, developers much better recognised the industrial features of automobile and the market demands. Such a change was also reflected as the market success of newly launched products. In 1992, the sales of *SHJ* climbed to near 50,000 sets, close to its designed capacity, and never fell down again. By these intentional changes of organisation and by learning, HaFei established its potential to

[123] Even the two-row-seater *WJ-120* was popular in the market (the market orders were beyond HaFei's designed capacity in the first year when this product was launched in 1988, namely 10,000 set/year), HaFei Auto was still severely short of finance since it had to feed the aircraft-making division. Therefore, although the first prototype of *SHJ* had been completed by the end of 1988, HaFei still had no money to build up facilities to produce this model. Only with the support from AVIC II and the regional government to arrange loans, could HaFei raise enough money to do it in 1991.

carry out obverse engineering product development, and was ready to be discovered by Pininfarina since 1993.

It is worth mentioning ChangHe, because its evolution provided an exactly contrast to HaFei about what if HaFei had not insisted its strategic intent or suffered to transform its organisation. ChangHe differentiated with HaFei from the beginning on. In 1983, MOAI issued an appointment that by imitating the *SK90*, HaFei developed a pickup model while ChangHe developed a mini-bus model. However, ChangHe gave up developing the chassis. It initiated a deal with HaFei that the latter would supply the chassis assemblies for it, while ChangHe could supply the bodywork[124]. Therefore, what ChangHe did was just to produce bodywork of mini-bus with low pace handcraft making (the capability it got expert in for its experience of aircraft making). In 1984, the negotiation between the Chinese government and Suzuki led to the imports of the *SK90* blueprints. As their prototypes and relevant facilities had already been developed at that time[125], HaFei and ChangAn did not change their schemes by taking the imported blueprints as references. Only ChangHe gave up its original plan and turned to stress the production localisation of the imported blueprints. In 1991, Chinese government negotiated with Suzuki again to import the blueprints of *SK410* for these SOEs as an upgraded product. As arranged, the three SOEs would buy 1/3 blueprints each in order to save money, and share them afterwards. Again, HaFei just paid its share and took the blueprints as references, since it had been preparing the industrialisation of the *SHJ* series since 1988. However, ChangHe broke up the deal. It raised more money to buy back the full set blueprints of *SK410*, and refused to share them with other two. Even so, it could not launch its new mini-bus platform until it established JV with Suzuki in 1995. After that, ChangHe became a typical Group-A firm and gave up the independence of in-house development force. Only after 2006, in response to social appeals, did ChangHe begin to develop an indigenous car model with the outsourced body design from the Bertone (Italy).

ChangHe had never placed itself to such a circumstance as HaFei did to transform its own organisation endogenously to establish effective in-house learning system. It had never suffered the pains to mobilise its different units and to explore the learning integration to carry out in-house product development in a new industry. It just made use of particular strength it had accumulated, and continuously relied on imported technical solutions and then on the foreign partner. It came out to be backward as to the technological capability for product development.

[124] However, since the bodywork of mini-bus was distinct from that of pickup, HaFei in fact still had to develop it in-house.
[125] For example, HaFei had already started to build up its special gear factory.

7.2.2 Telecom-equipment sector

In the telecom-equipment sector, the benefits brought about by reverse engineering for latecomers were conditional. Since the global telecom industry had been deeply involved with semiconductor and computer technologies, the underlying technical logics of frontier equipment had been shielded with encapsulated chips and compiled software codes. It was difficult to decipher the original knowledge by reverse engineering. Therefore, in the 1980s, most Chinese indigenous firms could develop low-end equipment only, such as PBX or small PDSS, because these products were simple in technical architecture and the chips that required were accessible by Chinese developers from the market. However, as for the large-scale PDSS models (>10,000 line/unit), namely the products occupying major market values, it was hard to study by reverse engineering. It explained why Chinese had to spend a lot of money in export the large PDSS, which reached about 30 billion USD during 1990-1995. About 80% of total investments in telecom networks were used to purchase the large PDSS and complementary equipment to build up the backbone and urban networks.

In fact, China was not late in starting the modern electronic industry since the mid 1960s. However, for decades in the "*GuiKou Management*" system, its electronic, semiconductor and computer industry was placed independent away from most other industries that could be relevant. It resulted in the weakness regarding the interdisciplinary applications, such as the automotive electronics, computerized numerical control machine tools, and digitalised telecom-equipment[126]. Domestic policy-makers and industrial practitioners did not understand the in-depth connections between different disciplines. It came out with not only a question whether the leaders were willing to reform the previous industrial system, but also a question whether the leaders knew what direction and how the reform should go. The *DS* series projects presented the best achievements the ministry-led domestic industrial community could obtain based on reverse engineering and adopting the traditional telephony technologies. By contrast, *HJD-04* was the milestone, coming from outside the range of previous industrial administration, which brought about the breakthrough for the entire domestic industrial community.

In the 1980s, most Group-B firms followed the traditional methods of reverse engineering and developed low-end products, influenced by the *DS* series, and benefited from the spillover of

[126] It resulted in the low rate of advanced equipment installed in China: in 1982, 29% of telecom switching were realised by step- by-step switches, 33.7% by crossbar switches. Digitalised and semi-digitalised equipment only accounted for 6.7%, most of which was procured from overseas in the"*43 Arrangement(s)"* and the "*78 Plan"* in the 1970s. The huge gap in capability between China and developed countries could be presented by the case of Shanghai Telephony, which was the parent SOE of Shanghai-Bell and ever an excellent domestic telecom-equipment provider awarded by the national industrial administration. However, during Aug. 1984 - Dec. 1985, Shanghai-Telephony quickly lost all customers of its crossbar switches as Shanghai- Bell was established with advanced PDSS model. Sales valued 2.7 million RMB were rejected from its previous customers.

governmental research accumulation. After the emergence of *HJD-04*, they were inspired with the new thoughts that indeed indicated the technological trajectory and technological integration.

7.2.2.1 Sources of technological spillover: indigenous technical exploration in the 1980s

DS series projects and *HJD* series projects represented two industrial forces of China in 1980s. As a complementary strategy to the TMFT policy, the execution of the *DS* series aimed at generating indigenous products through learning imported products. Its development process also reflected the merits and demerits of the industrial system to which it adhered. By contrast, the *HJD* series was led by an outsider to the MPT system. It reflected a spontaneous “invasion” of traditional telephony regime by the computer technology, and an “invasion” of MPT-led telecom-equipment industry by an outsider.

(1) DS series

DS series included the *DS-2000* project and the *DS-30* project. The *DS-2000* project aimed to develop a 2000-line/unit PDSS system by reverse engineering the *F150* model of Fujitsu. The *DS-30* project was the successor to the front one, aiming to develop a PDSS with capacity over 10,000-line/unit.

In 1981, China introduced a first foreign PDSS model from Fujitsu, named *F150*. The *F150* was in fact a model designed particularly for the Chinese market since before that Fujitsu had not had such a model on hand. Therefore, with the coordination from Chinese government, local engineers had chances to watch some developmental activities of Fujitsu, such as the communication with users, technical tests and system adjustments. In 1983, the *DS* series was started by imitating the *F150* mainframe. Projects was mainly led by two institutes of MPT, namely the No.1 Institute, which was in charge of developing the switch for local telephony in the “*GuiKou Management*” system so it led the *DS-2000* project, and the No.10 institute, which was in charge of developing the switch for long distance telephony so it led the *DS-30* project. Universities and other research institutes affiliated to the MPT played supporting roles.

However, the learning based on reverse engineering did not happen smoothly as expected. As we know, Fujitsu was a top world mega-computer provider. Therefore, its competences related to computer technologies were represented, but was encapsulated and compiled in the *F150* system. Especially it adopted a traditional centralised architecture for which its strength in semiconductor and computer provided the strong LSI chips to work as the centres within the centralised system. However, on the imitators’ side, technical experts of MPT had little knowledge related to computer technologies. Therefore, they lacked the ability to discover, analyse and resolve technical problems about the computer control. The Group-A telecom-equipment firms were supposed to be another important source for obtaining external new knowledge to the MPT system. However, as we said, what the local engineers got were just the skills for manufacturing and the management approaches for operations. As for horizontal cooperation, unless with the coordination of higher bureaus (ministry-level or higher), there were few official channels for involved developers to cooperate with experts from computer-related ministerial systems, although the relevant technical foundations were as well rather weak in China. Meanwhile, with the regulations of COCOM, advanced LSI chips were hardly accessible on the Chinese domestic market.

With these difficulties, the underlying technologies of *F150* were far beyond the absorptive capacity of Chinese engineers at that moment. The *DS-2000* system had to simply follow the centralised technical architecture of *F150*, and adopt core chips from Fujitsu although there was no official channel to buy these chips actually. In other words, *DS-2000* model could be regarded as the combination of a series of locally developed telephony functions with a core black-box outsourced from Fujitsu. The *DS-2000* project was completed in 1986, and was awarded by Chinese government. However, it was produced in very limited amounts, indeed with only two sets in 1986.

In order to solve these difficulties, MPT did aim to integrate learning within a wider context. In the subsequent *DS-30* project, with the coordination among ministries, MPT included other institutes such as the Shanghai Jiao Tong University and the Chinese Academy of Sciences to develop relevant software packages supportively. However, it could not change the fact fundamentally that the *DS* series projects were led by MPT research institutes in technology and governance. With the prototype launched in 1991, the *DS-30* model also suffered from the same bottlenecks as *DS-2000* did. It explained why this model only had a very limited market share and a short market life in China.

The development of *DS* series projects won a turn to get significant improved only with two conditions came true. First was the emergence of *HJD-04*, which changed the technical cognition of the *DS* developers. Based on it, they generated a better understanding about the underlying themes of digitalised PDSS systems, which means they got a guide to explore the previous “black-boxes”. They began to place computational technologies at the central of product system design. In their upgraded PDSS model, namely the *SP30* (100,000-line/unit), they developed connections among different switching modules by adopting matrix-wise decentralised structure and computational controlling technologies. Second was the entry into China’s domestic market of the foreign special IC design firms brought about by the dismissal of COCOM in 1994, which solved the problems of *DS* series and *SP30* in outsourcing central processors for each switching module.

In short, the *DS* series effectively mobilised resources within the range influenced by the branch-based industrial administration. This series did have trained a group of researchers. However, the *DS* series had not achieved success for the cognitive and organisational limitations of the administration system it was tied to, which limited its contribution to the domestic community in terms of both technical innovation and organisational innovation.

(2) HJD series

The *HJD* series opened up a different trajectory, for which we have analysed in the Subsection 4.4.2.2 and 5.3.3.3. Here we spotlight its implications to the domestic industrial community.

The developmental activities of CIT successfully achieved an integration of the computer technologies and the traditional telephony technologies in spite of the institutional barriers that still worked. Its decentralised structure with its technological innovation, namely the "*level-wise distributed controlling structure*" and "*replicated T-type switching network*", belonged to the frontier of the global industrial community.

HJD-04's success had the domestic industrial community realise the importance of computer technologies to the modern telecom application. To be specific, what it indicated was the integration of relevant technologies from different domains, and the organisational integration of different resources to realise the technical target (e.g. CIT and the support from PTIC and LTEP). As we said, MPT organised a "hostile" committee for the conference to decide whether *HJD-04* was qualified to be licensed in 1991. This committee consisted mostly of potential competitors of *HJD-04*, and was kept lasting for an entire month. It was a challenge to the *HJD-04*; but from another side, throughout the tough and long-lasting inspection, the technical architecture, working mechanism and network simulation of *HJD-04* were well demonstrated to all participants, including policy-makers of MPT, researchers from universities and institutes, and engineers from SOEs and Group-A firms. In other words, the conference *de facto* acted as an important event to diffuse the technology and reputation of *HJD-04* within the entire industrial community. Soon after *HJD-04* obtaining approval, even ZTE and Huawei, which were still small firms located south 2,300 km away from Beijing, had already known its technical solution.

In fact, some imported PDSS models, such as the *S1240* of Shanghai-Bell, also adopted decentralised control technology, although they displayed differences from the *HJD-04* regarding the practical solution. However, before these imported products or blueprints were shipped into China, their underlying technologies had been shielded by the packaged LSI designs and the compiled software. *HJD-04* was the only one accessible to the domestic industrial community varied diffusion ways with its underlying technologies quasi-open through. Meanwhile, *HJD-04* presented a pattern to set up the large-scale PDSS system by employing common chips. With a matrix-wise decentralised control structure, CIT enabled the *No. 244*, *No. 245* and *No. 374* chips which were standard chips on the market with small capacity to realise the modular switching functions and supporting functions, and adopted the *Motorola-68000* which was also small to act as the central processor. Considering the regulation of COCOM, it indeed opened a wide perspective for the domestic community in terms of technical cognition and practical solutions to pursue technological success and commercial survival.

In short, the success of *HJD-04* stimulated the institutional, organisational and strategic changes to overcome the barriers among different technological disciplines and industrial systems as response to the emerging technological and industrial challenge. The industrial community did obtain progress through learning upon it. For instance, right after the launch of *HJD-04,* the SPC reduced its funds for the *DS* series projects, but stressed more on emerging firms. All these made the *HJD-04* a milestone in the history of China's telecom-equipment sector, and changed the technical trajectory and organisational pattern of Chinese domestic firms, especially for Group-B firms.

7.2.2.2 Inceptive knowledge base of Group-B firms

In the late 1980s, there emerged over 200 new domestic firms that developed or did agent-sale of PBX or small PDSS. The newborn indigenous developers stretched their knowledge by studying foreign models and benefiting from spillover from governmental research accumulation. However, for the significant complexity of technologies embedded in large-scale PDSS, the relevant knowledge was not attainable to these newborn indigenous firms through reverse engineering. Moreover, there were no other relevant experience spillover from the domestic industrial community, since Group-A firms failed to obtain any significant process of product development in China.

Therefore, only the emergence of *HJD-04* inspired them with new cognitions. However, as the implications from *HJD-04* were new to the domestic telecom industrial community, these newborn domestic firms reacted differently. Only a few firms got success, such as ZTE and Huawei.

(1) Inceptive knowledge base of ZTE

ZTE was founded in 1985 by a group of engineers spin-off from the No.691 Factory (in Shaanxi) affiliated to Ministry of Aerospace Industry. In China, the aerospace industry was also regulated as quasi-military. Hence, the No. 691 Factory also confronted the reduction of governmental appropriation in the 1980s, and had to seek commercial opportunity to "make a living". Therefore, it sent a team to Shenzhen to explore the business opportunities.

At the beginning, ZTE was a small firm to produce household electronic appliances according to external business orders. It perceived the program-control telecom switch by chance: in order to sell his IC chips to ZTE, a Hong Kong dealer set up a very simple switch by his chips on a dining table in front of ZTE's engineers, to demonstrate that these chips could serve for multi-purpose. This model was tiny in terms of switching capacity, but shocked ZTE by showing a rough concept of program-control switching.

ZTE decided to enter the telecom-equipment sector. Its members had experience regarding the electronics and semiconductors technical development when working in the No. 691 factory. ZTE turned to the Post and Telecom-equipment Plant of Shaanxi Province (SPTE) to look for support related to the traditional telephony technology. SPTE had already developed a prototype of a PBX, which was based on analogue crossbar technologies, only with the capacity at 32line/unit. Their cooperation started from 1986, ZTE invested most of money it had earned to industrialise this model, namely the *ZXJ60*.

After that, ZTE started developing a PBX model named *ZX500* based on real digital technologies to realise the capacity at 500 line/unit, which turned out to be competitive in the niche market of small PDSS (for the restraint of budgets some regional telecom operators in marginal market adopted large PBX instead of small PDSS). For this project, ZTE asked Beijing College of Posts and Telecoms for help, and took one PBX from Samsung as reference of development. As a result, the *ZX500* was licensed by MPT in 1989.

At that time, MPT caught out an imbalance of telecom development between the urban areas and the rural areas, since MNCs and Group-A firms were not willing to serve the peripheral markets. Inspired by the popularity of *ZX500* and other domestic PBX models, MPT decided to encourage indigenous firms to develop PBX and small PDSS for peripheral markets. ZTE was one of the firms included in an official recommending list of MPT for telecom-operators in rural areas.

The appreciation of MPT brought some opportunities for ZTE to cooperate with governmental research institutes of MPT. ZTE was arranged to cooperate with the No.10 Research Institute to develop an upgraded switch. However, the cooperation failed for the disagreement about governance pattern between the two sides. ZTE turned to work with the Nanjing College of Posts and Telecoms forwardly, which had been involved in the *DS* series projects. During 1989-1992, a cooperative project was carried out to develop a digitalised 500 line/unit PBX named *ZX500A*. The high cost performance of *ZX500A* and the good customer services of ZTE won good reputations. ZTE accumulated most of the funds, which was used for the development of its large-scale PDSS.

In short, through a series of product development ZTE had accumulated an infant knowledge base, and got touch with domestic research resources. However, it still could not establish the understanding upon large-scale PDSS systems, since within the range of its knowledge search there was no relevant answer. Besides, ZTE had organised a development team consisting of the segments expert in switching technology, telephony technology, manufacturing, marketing, and post-sale services. ZTE called back its engineers from the production lines of household electronic appliances, and recruited some experts from its cooperative partners, including SPTE and Nanjing College of Posts and Telecoms.

Meanwhile, ZTE realised the fundamental organisational preparation during this period. The leading members had signed a contractual agreement with the No. 691 factory to ensure the autonomy of operational management. A further agreement was signed in 1993 that endowed the executive managers with the power of strategy making; as exchange, the managerial team, which was authorized by the ZTE collective, guaranteed the revenue growth rate to investors by taking on the stock share of the collective of employees as a mortgage. Therefore, ZTE, as a SOE in theory, turned out to be a firm controlled on its own managerial team, away from the turbulence of China's reform of SOEs during later periods.

(2) Inceptive knowledge base of Huawei

Huawei was established in Shenzhen in 1987. REN had absolute authority within the firm, and got support from his following elite engineers for his aggressive intent regarding the indigenous product development.

Huawei started its business from doing agent sale of HAX PBX products of KangLi (Hong Kong). One year later, Huawei decided to develop its own PBX model in spite of the opposition from its Hong Kong partner. It cooperated with a team from Tsinghua University and developed a 500 line/unit PBX named *HJD48* based on analogue technologies. *HJD48* was not an advanced model, but succeeded in satisfying rural customers and hotel customers. Its business success provided Huawei most financial resources for its further development until the launch of *C&C08*, namely its first large digitalised PDSS model. After the success of *HJD48*, Huawei started a new project to develop a 1000 lines/unit PDSS model based on analogue technologies, namely the *JK1000*.

However, even with the smooth progress, Huawei had not accumulated effective knowledge about the large-scale PDSS[127]. What its engineers did was to follow an incrementally progressive trajectory. So as they had already developed a small-scale PBX based on analogue technology, and were developing a small-scale PDSS based on analogue technology, the next step which had been in their plan was to develop a small-scale digitalised PBX or PDSS. As for the large-scale digitalised PDSS, the prospect was still uncertain.

However, Huawei had already made good preparation in organisational building. Since the

[127] For example, around 1990, REN was still considering about a project to develop an only 200 line/unit digitalised PDSS model when he contacted overseas Chinese engineers in the Silicon Valley.

beginning, REN had scheduled a team for indigenous product development. The transformation of governmental industrial and research systems caused experienced engineers and researcher left their previous posts and migrated to Shenzhen for new opportunities. It benefited Huawei's organisational expansion. By recruiting all experienced engineers they could obtain, all members of Huawei in its inceptive stage had technical backgrounds, even including the sales representatives. In 1990, Huawei had already gathered 600 personnel, most of whom were experienced engineers.

Strong strategic intent was also optimising this team. As we said, the insistence of REN and other core members on new product development engaged most internal finance resources and loans. Two founding partners left Huawei for their disagreement against the ambitious intentions, so did some common engineers if they wanted to avoid the great uncertainty that Huawei was undergoing. At the end of every financial year, after the annual bonuses were distributed, there emerged groups of resignation. The rate of staff turnover was as high as 30-50% and such a situation was constant until the launch of *C&C08*. However, from another perspective, it also preserved a coherent organisational culture that engineers who stayed stably all shared similar intent.

In 1992, in spite that the *JK1000* was still under development, Huawei stopped its previous scheme and started to develop the large-scale PDSS, because the implications of *HJD-04*'s success changed the views of Huawei about learning and development.

(3) Knowledge diffused from HJD series to ZTE and Huawei

As regards the mechanism of technological diffusion from the *HJD-04*, the 1991 inspection conference acted as a critical event. After that, the MPT organised training programme to spread the successful experiences of domestic PDSS development, which was open to the entire domestic industrial community[128]. Meanwhile, the GDT alliance, which included a series of SOEs around the entire country, also enhanced the indirect technological spillover, without mentioning that there were a dozen of others producing *HJD-04* without the permission of GDT.

Group-B firms also got direct diffusion from the *HJD-04* project. CIT, namely the development team of the *HJD* series, was quite open to domestic requests for technical consultancy as it still partly inherited the tradition of the central planning era. Huawei organised visits of its engineers to the projects of GDT when the latter was constructing networks for its customers. REN invited three leading technical experts of CIT as consultants to Huawei for eight months; and WU even

[128] In 1992, MPT organised a training programme to spread the new technologies of PDSS development, including those of the *DS* series and the *HJD-04*. All domestic research institutes and firms were encouraged to take part in. Besides, MPT summarised the experience into a handbook, which was rough, but it still became an important guide for domestic PDSS development.

allowed his core follower to accept it. Even WU himself also provided advices and comments on the projects of Huawei occasionally. Similarly, ZTE also invited them to provide consulting services. When GDT ran into difficulties, some members of CIT joined the Group-B firms.

The inspiration from the success of *HJD-04* was firstly spiritual by echoing the ambitions of indigenous developers when they were still groping in dark. In our interviews, even if interviewees would have different ideas about the extent that they personally benefited from the *HJD-04* in technology, they all emphasised highly the spiritual encouragement they received. In fact, even for the policy-makers, the bitterness of *DS* projects ever brought them the sense of failure, but the success of *HJD-04* largely reversed the trend.

The Group-B firms perceived from the *HJD-04* primarily embodied as cognitions related to the technological development of PDSS. After 1991, there was no more new indigenously initiated PDSS model adopting centralised architectures of switching control, but all adopting decentralised ones, even though their similarities to the *HJD-04* system varied[129]. It did not mean to deny the centralised architectures in general, but reflected the progress of understanding about product systems and the strategic choices of domestic practitioners with consideration about particular circumstances. With the distributed control system, indigenous practitioners could adopt standardized or small LSI processors that were more accessible on the market. In fact, since the *HJD-04* had shed light on the core “black-box” of large-scale PDSS as to the relation between the computational process realised by the LSI chips with the switching and controlling functions required by the telephony application, leading Group-B firms got inspired and started to establish their strengths in the in-house ASIC development.

More importantly, *HJD-04* implied a new pattern of technological integration, by which CIT integrated the non-telephony technology with traditional telephony technology, and integrated the organisation from non-telephony division with the SOEs affiliated to the MPT. This success had domestic practitioners not only to follow the experience of *HJD-04*, but further to re-consider the patterns of searching knowledge and the relevant organisational formation, the outcomes of which were certainly different from the traditional expertise distribution and interaction influenced by the branch-based industrial administration. ZTE and Huawei actualised their organisational transformations during the development of large PDSS models. The contents of transformations were similar to the building of cross-boundary inter-departmental platforms in Group-B car-making firms. By doing so, they created the flexible organisational platforms to solidify the technological integration to cope with the dynamic product and service oriented competition,

[129] The *ZXJ10* of ZTE, the *C&C08* of Huawei and the *EIM-601* of JinPeng all adopted decentralised architectures technically. Even the *SP30* model of DTT, except for its inheritance from the *DS-30* in individual modules, also adopted a distributed controlling structure to connect different modules.

rather than just integrating technologies and personnel statically for one project.

With the internal organisational changes, the active employment of external technological resources was a critical method to realise technological integration, especially taking use of the resources of the governmental industrial and research systems. To take the development of Huawei's large-scale PDSS, namely the *C&C08*, as an example. The project was primarily based on the cooperation between Huawei with the No.10 Research Institute. Later, some researchers left the No.10, and joined Huawei. Up to 1992, for the *C&C08* project, Huawei had already gathered experts from SOEs (e.g. the Changchun Telephone Equipment Plant), research institutes (e.g. the Research Institute of Data Communication of MPT), universities (e.g. the Huazhong University of Science and Technology), and so on. As for other projects, external cooperation was also a major method. For example, Huawei cooperated with Beijing College of Posts and Telecoms on ISDN (Integrated Services Digital Network), with Xi'an Electronics Science and Technology University on ATM (Asynchronous Transfer Mode), with the Research Institute of Data Communication of MPT on STP (Signalling Transfer Point), and many others.

Only after 2000, leading Group-B firms discovered they could not directly benefit from the technical resources accumulated by governmental S&T system for their projects any more, as they had already become leading players within the domestic community. However, their cooperation with external institutes was still maintained with more emphases on training personnel and mid and long-term technical exploration. Such an arrangement had been solidified, since as a by-product of external cooperation Group-B firms had established a series of R&D centres in hot-spot cities around China. ZTE had research centres in Nanjing, Shanghai, Beijing, Xi'an, and Chongqing, while Huawei had in Shanghai, Beijing, Nanjing, Xi'an, Chengdu, and Wuhan. These centres continuously worked as agents to make use of the external technical resources, and as professional developmental forces.

Inside the Group-B firms, as we mentioned, the expertise that they recruited included people from various places and with various disciplinary backgrounds, including the traditional electro-magnetic telephony, radio, computer technology, semiconductors, materials, optical physics, and so on. The internal institutions aiming at the dynamic technological integration engendered the motives and flexibilities for them to do so. For example, during 1993-1995, 50% of new-coming members in Huawei were with software engineering backgrounds, which was definitely unimaginable in any traditional telephony equipment provider before.

The organisational integration of expertise with different technological backgrounds did help to cope with the rising product-oriented competition. When Huawei developed its *C&C08* version to realise over 10,000 line/set, developers had to connect different modules with a control module (2,000 lines for each switching module of *C&C08*). The communication among different modules required fast and large data processing capacity. Usually, this should be according to the Intel Multi-bus II standard, which was broadly adopted, such as by the *F150* of Fujitsu, the *S1240* of Bell, and so on. Huawei met difficulty to achieve the processing of massive data at high speed with the bus. Then the developers decided to adopt optical fibre transmission. At that time, the application of optical fibre in the telecom-equipment sector had not yet been mature. Only the *5ESS* model of AT&T adopted it, but *5ESS* was generally regarded as the most advanced PDSS contemporarily. However, since the chief and some other leading engineers of the *C&C08* project had the background of optical physics, they made such a decision, although none of them knew any technical detail of the solution in *5ESS*. Importantly, the organisation supported them with resources to risk, and with close interactions relevant colleagues knew their idea well and could give fully support. They succeeded in this attempt. It also opened the perspective of Huawei in applying optical fibre technology, which was proved later to be the trend of the global industrial community. Relevantly, the early move brought Huawei advantages in developing the SDH (Synchronous Digital Hierarchy) equipment, which adopted optical fibres as its fundamental transmission medium.

Along with the above transitions, ZTE started the development of *ZXJ10* in 1993 and launched this model with 10,000-line/unit after 18 months. Huawei launched the 2,000 line/unit *C&C08* model in 1993 and the 10,000 line/set model in 1995.

7.2.3 Summary

The building of inceptive knowledge base was far beyond pure technical exploration. The organisational expansion, the integration of knowledge carried by individuals, and the stretch of knowledge base were critical issues happened to Group-B firms in this stage. The active interaction among individuals was critical to realise inceptive knowledge integration, especially for the re-codifying of implicit knowledge or tacit knowledge, and the deepening of mutual understanding. Behind these processes, there were support from their organisational learning systems. Strategic intent and resource allocation caused the organisational cohesions, and ensured the investments for practical projects that worked as fundamental platforms of the above integration. As we see, the cross-boundary inter-departmental platforms provided the organisational foundation for knowledge integrating and stretching.

Therefore, the dynamics of Group-B firms could not be explained purely as the growth of technological expertise. In fact, even after Group-B firms had laid their groundwork of knowledge base, many Group-A firms still had advantages in product technologies regarding their accumulation before. For example, what Geely had achieved during 1997-1998 in terms of the technical advancement could have not been comparable to the "*SanKouLe*", which was developed spontaneously by a group of engineers of FAW in their spare time in the early 1990s. In another case, regarding the emergence of indigenous technical breakthrough, such as that of *HJD-04* in 1991, Group-A firms and other traditional governmental industrial entities had much better chances to get touch with the know-how of *HJD* series, but seldom did they seize the opportunity to generate real actions to develop any technology or product after being inspired. Even though some newborn firms, such as the ChangHong during 1991-1995, did successfully develop their own large-scale PDSS based on the excellent technical expertise they gathered in-house. However, without internal organisational transformations, they failed in coping with the dynamic product-oriented competition.

7.3 After the Inceptive stage

7.3.1 Introduction

The technological learning of Group-B firms after the initial stage happened simultaneously in the divisions of production lines, product development, long-term technological exploration, machine tools development, and the developmental activities based on their crossing-boundaries platforms. Without market protection, Group-B firms must compete with domestic incumbents and global giants on Chinese market. In practices, Group-B firms had common intent as to building up multiplex product platforms, because the business based on small number of product lines was fragility in case competitive rivals were intended to attack them by price wars. Thus, developing their own products was still the urgent task for their learning and business operation.

Practically, the business strategy of Group-B firms could be summarised as the "*XiaoBu KuaiPao (running quickly with short steps, RQSS hereinafter)*" in general. By this strategy, the progress achieved by each step or each project was not expected to be a large move from the previous knowledge base. Rather, Group-B firms expected to gather small moves into large progress. Therefore, practical projects were implemented parallel, and generation by generation. There were overlaps of participants among different project teams, which induced tight communications among them. Iterative trials and gradual improvements were relayed among different projects, and along the sequence of projects. The mid- and low-end market segments tolerated the trials embodied in product outputs of Group-B firms if the firms could respond quickly to the shortages or mistakes as they were indentified.

In the following subsections, we do not mean to focus on the business strategy and survival, but concentrate three major mechanisms of Group-B firms in creating new knowledge, namely learning through recruitment, learning through cooperative projects and learning through interactions with customers. These three mechanisms could not cover all the scope of their kind, but we draw them from the empirical studies as regards their distinguishable roles in obtaining knowledge of new categories that could not be generated by repeating the existing activities.

7.3.2 Learning through recruitment

As analysed in the last section, integrating knowledge borne by new recruited members was critical for Group-B firms to establish their in-house knowledge base. In fact, since Group-B firms grew from small teams, continuously recruiting excellent personnel from outside was important as response to the needs for promoting the scale economies of organisation and knowledge. In practice, a strategy of personnel-intensive R&D was remarkable for Group-B firms in technological learning. However, comparing with Group-A firms that also took the Chinese labour supply as advantage, what Group-B firms stressed was the activation of large amount of well-educated engineers in addition to the labours for production lines.

For instance, ZTE hired nearly 9,000 personnel in R&D personnel in 2005, and the number rises remarkably to over 20,000 by the end of 2008. In 2009, ZTE is enlarging its Nanjing Centre for R&D. As to the plan only Nanjing Centre will engage over 20,000 R&D personnel. The number of R&D personnel for Huawei was over 35,000 in 2007, and exceeded 40,000 in 2008. In the car-making sector, more than 6,000 engineers and researchers were hired by Chery out of about 20,000 employees in total in 2008. Among them, about 3,000 were freed from routine operations of production lines, and centred on product and technology development. In BYD Auto, it had 3,000 R&D personnel in 2006. By the end of 2007, the number increased to 5,000 only in BYD's Shanghai Centre. Considering that it just entered the car-making sector in 2003, it was a fast growing rate. Geely also employed 1,600 engineers in R&D in 2008.

In this subsection, we summarise the practices of Group-B firms' learning through recruitment into three categories by the sources of employees, namely the local experienced engineers, university graduates and overseas returnees. The effectiveness of Group-B firms' integrating recruited personnel into the in-house organisational learning systems was the highlight.

7.3.2.1 Local experienced engineers

Chinese institutional systems introduced the mobility of the domestic human resources, and brought about possibilities for Group-B firms as they looked to make use of existing talent assets that had been accumulated by the central planning system previously.

The local experienced engineers worked the core portion of Group-B firms' in-house human force in early phases. In fact, in early phase, local experienced engineers contributed to the major part of the organisational expansion of Group-B firms. Group-B firms did also hunt expertise intensively. For example, Geely at the same time obtained 3 former vice directors of FAW’s R&D centre (data from 2005). In the telecom-equipment sector, the No. 39 Research Institute of MEI (Ministry of Electronics Industry) suffered much from the brain drains to Huawei and ZTE. As its former researchers came back to attract their colleagues and successors ever and again, The No. 39 Institute ever could not carry out large projects during 1995-1998 since it could not even form up an complete team for the projects. As their financial strength got enhanced, Group-B firms even could compete against Sino-foreign JVs for human resources. Qingdao-Lucent ever lost almost half of its testing team since these engineers got better offer from Huawei to participate in product development, and got better pay.

The knowledge that local experienced engineers had obtained was not new to the domestic innovation system. However, the combination of their knowledge could be new. The integration of their competences constructed the collective knowledge frameworks of Group-B firms in their early phase. From a knowledge-based view, the integration realised by Group-B firms promoted the values of knowledge that had already existed on local experienced engineers, as it formed up a sharp contrast against the situations in the former central planning system and in Group-A firms. The pattern of Group-B firms bridged the S&T research with the industrialisation demands. The experts in different technical domains were not anymore regulated respectively by branch-based hierarchies. Moreover, they got fuelled with strategic resources to implement developmental projects at the centre stage of learning within firms. Working in Group-B firms, local experienced engineers from research institutes and universities were no longer distanced from the practical industrial applications in this stage. As well as the colleagues coming from SOEs, they turned to be executors of practical projects or to provide services aiming at industrialised needs. Resources were authorised to them to realise close interactions in real time, without administration for professional regulation. For example, under the previous industrial administration, engineers specialised in the ECU (electronic control unit) for engine injector control had to pass through higher bureaus to communicate with engine developers if the latter were not their appointed partners. It was the same for the RF (radio frequency) developers. As most of them belonged to the No. 39 Research Institute of MEI, in the face of emerging challenge of mobile telecom, it was difficult for them to realise tight interactions with the telecom-equipment developers affiliated to MPT unless they got coordination among ministries. After many of them moved into Group-B firms, they could work closely with colleagues from relevant domains or from domains that were ever regarded as non-relevant.

The integration of their knowledge, and the relevant further knowledge creation were efficiently achieved only based on the cross-boundary inter-departmental platforms and through practical projects. As we had analysed it for the situation in their inceptive stages, for the sake of brevity, we do not elaborate the similar situation here again.

7.3.2.2 University graduates

Before 1998, the recruitment of university graduates was regulated by government, associated with a series of institutions about social welfare and household registration. Being jointly assigned by the government with a career was both the right and the obligation of university graduates. Through the governmental job assignment system, graduates were offered stable, quasi-lifetime employment. Otherwise, they had to risk their life-time career.

From 1994 on the regulation became flexible, and 1998 was the first year when the recruitment of graduates was deregulated. Firms were allowed and then later encouraged to access the university student. As soon as they got the rights, Group-B telecom-equipment firms raised a "brains war" on campuses. For example, in Tsinghua Univ., a top university in China, Huawei and ZTE enrolled more than one hundred graduates who would be entitled with doctoral or master degrees in 1998. Finally, the administration of Tsinghua had to stand out and cease their on-campus advertisement since the university regarded it as not good to have large numbers of its graduates to compete with their alumni toughly in a same firm. In 1998, ZTE and Huawei enrolled about 3,000 new graduates respectively in total. In that year, the statistics of Ministry of Education revealed that about 20% graduates in the telecom and computer relevant departments from the top 20 universities in China were hired by Huawei (Wu and Ji, 2006, p155). Among these top-20 universities, as to those affiliated to the MEI or MPT previously, such as XiDian Univ., the Univ. of Electronic S&T of China, HUST, the human resource departments of Group-B firms tried to have job talks with every graduate from relevant departments, in spite of whether specific graduates had made a forward request or not. By doing so, Huawei obtained nearly half of master graduates from relevant departments of these universities. In the Nanjing R&D centre of ZTE, it could be discovered that former teachers of Southeast Univ. (Nanjing) were working with their former students as ZTE had recruited many personnel from their labs.

In Group-B firms, the large numbers of junior engineers got guidance from their senior colleagues and grew rapidly up from intensive practical projects. They worked as the major executors of the "personnel-intensive R&D strategy" of Group-B firms, which meant to invest comparatively large number of engineers onto each involved R&D domain at centre stage of their technological learning. Group-B firms were generally observed with this feature, and Huawei was the most famous for its "Pascal's Principle", by which Huawei insisted to form up advantages of R&D personnel intensity in each hot-spot segment it engaged than its major competitors did. The massive annual new graduates in China provided the robust sources of well-educated junior engineers[130].

The personnel-intensive R&D strategy enhanced the intensity of learning activities, and increased the gross productivities of learning. Based on the technical modularity and the basic integration capability of Group-B firms to layout the technological frameworks, this strategy increased the divisions for professionalization, which yielded comparatively better performances of learning. It also brought about the diversity of knowledge by integrating the learning of many people with different ideas, which potentially offset the lack of experience of Group-B firms to some extent. Therefore, for the development of LTE, which was at the frontier of the current global telecom industry, ZTE invested more than 2,000 engineers (data from 2006). On developing only the battery system for its *E6* model of electric automobile, BYD gathered 500 engineers (data from 2007). As for mature designs, the personnel-intensive strategy brought about potential advantages in realising the incremental improvements. Group-B firms invested groups of engineers on works as detailed as each part and each technical feature, which helped to continuously promote the quality and lower the cost. Chery even employed over 400 engineers professionally in further product improvement after SOP (Start of Production) (data from 2006). In the telecom-equipment sector, learning from interaction with customers was an important source of knowledge. The inputs with large groups of engineers could also promote the depth and breadth of interactions. For example, Huawei organised over 14,300 engineers to provide post-sale engineering services (data from 2007).

However, the effectiveness of this strategy and the competences growth of junior engineers resided in the organisational learning systems, rather than recruiting people only. The organisational systems of Group-B firms kept junior engineers at the nodes of in-house learning network that were highly active for the large number of relevant projects, and were highly sensitive to interwoven teams and cross-boundary knowledge communication. For instance, in Chery, the average age of its in-house engineers was 24 while the average amount of projects engaging each engineer was 12 (data from 2006). Geely had only 200 engineers at its R&D centre in 2003; but in that year only, in addition to the tasks for current industrialised projects, these 200 engineers completed more than 5,000 digital models for cars, assemblies and components to strengthen their knowledge accumulation. Thus, when Geely carried out the *CK-1* car model project during 2003-2006, all digital models for 412 designed modules were completed in-house, although they had the Daewoo International as an external consultant for the bodywork design. It demonstrated how fast the junior engineers grow up. By contrast, when DongFeng-Citroën optimised an engine for *FuKang* which was finally launched in 1998, it cost 3 months for the JV

[130] In 2003, the annual new university graduates were 2.12 million, and 6.31 million in 2010. (source: *China Education Statistics*)

team to engender just 1 digital model of component supervised by a Japanese technical firm appointed by the French side.

By contrast, Group-A firms were not so incentivised to train junior R&D forces, since their major activity was to expand their product capacity. For example, in 1992, namely the 9th year after it was founded, Shanghai-Bell had already established one more new factory and one more JV as production bases. However, it only had two rounds of large-scale recruitment of university graduate after its set-up, namely one in 1991 for recruiting 80 graduates and one in 1992 for 100 graduates. Both were to train post-sale service engineers and managers for workshops.

7.3.2.3 Overseas Chinese returnees

Integrating knowledge carried by overseas returnees was also an important source of learning in Group-B firms. In general, the overseas returnees hired by Group-B firms were also experienced engineers. Therefore, our analysis about local experienced engineers is also applicable here. But, we specially point out the overseas returnees because employees from industrially advanced countries are widely taken as important impetus for the transitions of latecomers from lower stages to higher stages in terms of capability, as regards the literature stressing the bottom-up step-wise catching-up of firms in DCs. For example, Kim (1997, p90) notes "*...Late entrant firms acquire technological capability by stealing experienced technical personnel from the early acquirers...*" Other scholars, such as Teece (1977), also take the move of personnel as a critical method of technological transfer, especially of tacit knowledge. However, we insist the practical effects of the transfers in question ought to be studied as real organisational processes.

The role of returnees as to the in-house learning of Group-B firms could be summarised into two categories. The first group worked as leading engineers to organise learning of department(s) or entire firms. The second group focused on technical exploration within specific domains, worked as specialised experts, or led some first-tier specialised suppliers. To take Chery as example, in 2007, there were about 12 returnees working as learning organisers at the firm level, about 30 as technical experts in professional domains, and over 30 as leaders of affiliated supply firms.

The recognised returnees had experience as working in leading MNCs. By comparison with local engineers who had not ever experienced in advanced stages, they in theory seemed to be more capable in leading technological learning of Group-B firms aiming at advanced stages of development. People called those returnees who worked as learning organisers in Group-B firms as "returnee stars". That was for the high expectations of stakeholders on them. However, practically, according to the experience in Group-B car-making firms, returnee stars could meet difficulties in several aspects, mainly relevant to the existing in-house organisational learning systems.

First, most of them were green in management since it was generally difficult for overseas Chinese to attain managerial posts in leading MNC car-makers except for very few exceptions. Thus, they could potentially be maladjusted to organise departments or firms to achieve complicated, multi-technology and multi-interest learning.

Secondly, even for technical development, most returnee stars had little experience as technical integrators. Before joining Group-B firms, they just worked as technical experts in specific domains in MNCs, and barely had experience in carrying out practical car or complex technology development projects. In many cases, they had not realised the importance of close interactions in real time between different domains when Group-B firms carried out developmental projects in this stage. Rather, they were inclined to isolate their developmental activities within small professional domains, or to excluded other relevant groups as to sharing the in process knowledge. Generally, they were duplicating the experience they ever witnessed in giant MNCs, with which they tried to justify themselves. But they were also possibly trying to protect themselves from challenges of relevant co-operators or even subordinate teams, as their deficient knowledge in leading complex projects led to their weakness regarding the cross-boundary inter-departmental platforms, with which their protestor (also should be their learning co-operators) criticised them. At least, according to our opinion, they were trying to duplicate the previous experience in MNCs which ever endowed them powers and won them respects from Group-B firms, namely to work as technical experts to process the appointed tasks just professionally in their fields. For example, XU Gang, who was ever appointed as the vice-president of Chery in charge of R&D during 2003-2006, had worked as senior expert in Ford, GM, Delphi and Visteon during 1995-2003. However, his mastery was only in the combustion process around the fuel injection within the engine. As leader of projects in Chery, he broke down the existing routine of development, and refused to interact with relevant units and assistant firms in real time or even by periods. His tenure delayed a series of product projects of Chery's and was ended by a disrepute event.

Thirdly, returnee stars were not knowledge gatekeepers in industrialised projects of MNCs before. Therefore, they were less aware of practical industrialised trade-off and usually advocated advanced technical applications which were often resource demanding and beyond the current capabilities of supporting engineers and suppliers of Group-B firms. The *S12* model of Chery was a typical example. After taking over the in-progress *S12* project, returnee stars denied many existing design details, and suggested a series of adjustments, including a replacement of the suspension system. Certainly, some suggestions brought about benefits for the project. However, many of them were just experimented by them in laboratories. As results, some adjustments were phased out for the inconvenience regarding mass production; some others were insisted by the returnee stars, but were obviously beyond the capabilities of front-line engineers and suppliers. Finally, *S12* became a bad-performing project in Chery's history. It was delayed by 18 additional months (note that the development cycle of a new car model in Chery was only 18-24 months at that time) and cost much more investments than schemed. The launched car model was out of control in production cost (especially the complicated suspension system cost much), and was not welcomed on the market for its incongruity bodywork.

From another perspective, the advocacies of failed returnee stars were also incompatible to the RQSS strategy that was implemented by Group-B firms as a basic strategy for business survival and technological learning. Returnee stars stressed regular, step-by-step procedures of development, and tried to fix most problems beforehand. They highlighted the professional-based pattern among different participating units with periodic interactions only which seemed to be clear and efficient, and criticised the intensive in-progress interaction among units as the source for chaos and technical faults. However, as lacking the well-established systemic or mutual understanding, cooperative units in Group-B firms required frequent interaction to refine their common understanding toward the collective developing targets, and even to enhance their knowledge or even confidence about the progress of each other.

The incompatibility was also demonstrated by the lower-level organisation. In 2006, for the brains-drain, the department of engine development in Chery, which was absolutely dominated by returnee stars at that time, shrank in scale of personnel. Young engineers left for frustrated feelings that the environments were not as good as expected. The shrink of a major unit was the first time and the only one time in Chery's history to date.

During 2006-2007, a series of broken-up happening between Group-B firms and returnee stars ended the fever of regarding returnee stars highly as learning leaders. The failed returnee stars prove to be inexperienced as to the social technologies that Group-B firms had been developing and were to develop. They failed to acclimate themselves and transferred the knowledge they had obtained into the new organisational environments. The higher-order rules of learning that they generated from their previous unrelated experiences were finally not internalised by the organisations that had their own memories about successful learning on hand. Alternatively, the returnee stars should accumulate the knowledge about learning organising through their own practices in Group-B firms. Indeed, some returnee stars did achieve remarkable success in this way, such as ZHAO FuQuan in Brilliant and Geely, and YUAN YongBin in Chery.

By contrast, the success rate of returnees as technical specialists was much higher, because these returnees did not have to coordinate learning within a large range both in organisation and in technology. In Chery, around 30 returnee experts worked in R&D departments, and more than 30 returnees led core suppliers co-invested by Chery (data from 2007). They focused on their specialised fields, and showed willingness to be integrated by the ongoing organisational routine. These characters won success for them in Chery.

7.3.2.4 Summary

The learning through recruitment is realised on the organisational framework. Only with the aggressive strategic intent regarding indigenous product and technology development, Group-B firms would implement personnel-intensive strategy and recruit large amount of R&D engineers, whereas large-scale recruitment of R&D engineers had never happened in Group-A firms. Besides, the knowledge borne by individuals would not naturally be useful to the collective learning. Individuals must be cultivated and interacted with colleagues under the higher-orders embedded in the new "organisation-technology-product" platforms to realise the mutual understanding and adjustment, and then the knowledge integration and further creation. Such processes were not achieved by academic forums, but by practical development projects. Thereby, again, the resource allocations that favoured the product and technology development and the supportive authorities were critical. Knowledge accumulation facilities also contributed to the knowledge diffusion, conversion among individuals and the cultivation of junior engineers.

The experience of failed cases of learning by recruitment highlighted that the organisational learning systems worked as a filter of learning in addition to as a platform to facilitate. Knowledge conversion was not realised within a vacuum but required practical platforms, which consisted of the loci, participants, activities, absorptive capacity and schedules along time. Within the organisations, the abilities to absorb were uneven across different departments or different groups of participants (Dutrénit, 2000). Then the successful knowledge conversion relied on the performances of activities along the schedule, through the products or services as the agents to interact with market. In process, it also relied on the appropriate relations between the learning organising with the organisational institutions, the collective knowledge possession and the organisational knowledge distribution in real time. The advancement of target knowledge could not ensure the penetration of organisational system. The failure of some returnee stars exactly demonstrated that their knowledge inputs, including their advocacies of physical technologies and social technologies, got rejected by the organisational systems with practical consideration of technology and product development.

7.3.3 Learning through external cooperative projects

Cooperation with external partners, either with international or domestic co-operators, was an important source of new knowledge acquisition of Group-B firms. Generally, the method by exploiting external cooperation to overcome in-house bottlenecks was not invented by Chinese firms. However, to employ it as a schemed, regular and underlying source for in-house learning was an innovation to Chinese industrial community. As mentioned, the cooperation of HaFei with

Pininfarina since 1995 opened this pattern among Group-B car-making firms. In this subsection, we stress the mechanism that they search, generate and accumulate new knowledge through external cooperation.

When the cooperative projects were held in the foreign sides geographically, in order to obtain knowledge through the developmental activities, Group-B firms sent out teams of engineers to external partners. For instances, Geely insisted on a “2:1” principle which meant it put in at least double in number of engineers than its foreign partner did. In Chery, during 2002-2005, over 1,000 man-times were sent by Chery to work and learn with foreign partners; and 70% of fees in terms of training expenditure were consumed by overseas learning. By learning through external cooperative projects, engineers of Group-B firms grew fast in technical expertise. For example, the chief engineer of Chery in the cooperative programme with AVL, namely Prof. HU (she has a professorship from the Tsinghua Univ.), in her sixties, got reactivated and re-organised for her expertise through the Chery-AVL projects. After 3 years’ cooperation with AVL, HU was even invited officially by AVL to be a leading engineer of AVL to take charge of a division. In another case, FANG Yunzhou, namely a young engineer, grew into a leading expert in the domestic community of electro-automobile only in his early thirties. The competences of FANG were built through 6 years’ practical projects invested by Chery; among the 6 years, he led 3 years’ cooperation with Ricardo. With the capability growth of FANG and his colleagues, Chery was regarded as from nobody into one of domestic leading players in the governmental electro-automobile project organised by the Ministry of Science and Technology.

However, we shall not consider the learning through external cooperation as an automatic process of knowledge inward piping. Foreign sides would not be happy to see the continuous capability growth of Group-B firms for the consequent reduce of their comparative technical advantages. The case of Brilliant Auto before 2004 also revealed that, without effective in-house institutional settings, external cooperation could help seldom as to the in-house capability building. Therefore, by contrast with conventional literature focusing on the trade-off about outsourcing or learning through alliance linkages (such as Hagedoorn and Schakenraad, 1994), we shed our lights inside the Group-B firms, to study how they realise knowledge searching, generation and accumulation through the external cooperation.

7.3.3.1 On-site knowledge searching and learning

As we said exploiting the external cooperation was a general phenomenon, we cannot distinguish Group-B firms from other domestic firms if stressing only the quantity of engineers sent to external partners. In fact, overseas training was also a recurrent event held by Group-A firms. In some cases, the amount of engineers sent by Group-A firms was also large. For example, in the mid 1980s, the number of Chinese engineers sent to Germany by Shanghai-Volkswagen was no less than 100 at any moment. Among them, 20 quotas were regularly set to stay in the designing department of Volkswagen for at least two years for each in order to train Chinese engineers for building up the Technical Centre of Shanghai-Volkswagen, which was supported by a fund as 3% of the revenue of Shanghai-Volkswagen (Liu, 1992). In 1990s, the team sent by FAW-Volkswagen to Westmoreland to study the production lines comprised 120 selected domestic engineers. In the telecom-equipment sector, in 1985 alone, Shanghai-Bell sent generally 60 engineers to Belgium. In addition, we cannot say the overseas training of Group-A firms was simply ineffective. As we said in previous chapters, many founding members or senior engineers of Group-B firms also benefited from these programs of Group-A firms for building their expertise at that time.

However, the differences between the practices of Group-A and Group-B firms in learning through external cooperation were still distinguishable. Engineers sent by Group-A firms were mostly present for training to manipulate imported components and equipment, and for relevant checking and taking-over. The knowledge they could access was well schemed by MNCs in serving the building of factories in China or the productivity growth at workshop level. As for Chinese engineers visiting the departments of foreign sides in charge of developmental tasks, they were arranged as interns or assistants to foreign experts since there was no relevant practical developmental project of Group-A firms on those cooperative platforms. At most, partial design skills were taught in order to implement those localised adjustment projects, such as the team of DongFeng-Citroën in France.

The pattern employed by Group-B firms was different, exhibited by the contents, platforms and dominant powers of learning. Delegate engineers of Group-B firms did not learn contents well-schemed by foreign partners. They were sent to master the dynamic process of the ongoing cooperative projects, namely to witness and participate in the real process of development. As their participation was termed by the contracts as an underlying part, not an accessory part of the advancement of projects, they were located on the same platforms with foreign engineers. Certainly, foreign partners would try to conceal or protect their intellectual assets such as the core databases. However, Chinese engineers at least got shared all the foreground information, which was dynamic and underpinned by the development mechanisms of foreign partners. Moreover, Chinese teams had the dominant role of the developmental process of cooperative projects, which was critical to ensure that the contents and platforms of learning to be implemented as what had been set by both sides beforehand. The dominant role in question derived from the financial investment in these projects made by Group-B firms, and embodied as the concrete clauses in contracts, and the technical inspection and confirmation rights possessed by Group-B firms. In order to proceed with the cooperative projects smoothly, foreign sides had to respond to the rational and relevant technical questions put forward by Chinese sides, or even had to teach them by details.

As we have analysed in the Textbox 5.2, foreign partners did not mean to open their intellectual storages to the Chinese learners at beginning. In the "*ZhongYi*" project, after Chinese delegate engineers found that the Italian side was doing this cooperative project as a turnkey project, and their participation was heavily restrained, they protested against the Italian co-operator. In order to comfort the Chinese delegate co-operators, Pininfarina arranged a seminar given by a senior designer, in the name of spreading critical techniques adopted in the cooperative project. However, the seminar came out to be an introduction lecture of painting at amateur level. To be honest, it might ever work as the reception of Pininfarina to cater the delegate teams sent by its Chinese co-operators previously, because if those Chinese engineers were not really incentivized to master the developing process they would enjoy this casual lecture and reported to their boss as they had already attended some training in the foreign side. However, this time, the Chinese engineers of HaFei were irate. They announced a strike, and refused to cooperate with Pininfarina anymore. Out of Pininfarina's expectation, the protest got support from the headquarters of HaFei. HaFei's delegate team was encouraged to fight for their just demands according to every detailed clause they had set in the cooperative contract for learning. The each piece of design must be inspected and approbated by the Chinese team. Otherwise, the delegate team was authorised to cease the cooperation without paying Pininfarina the rest money. Finally, the Italian side had to accept the requests, and the delegate engineers of HaFei got on the same working platforms with their Pininfarina colleagues.

It became a common tactic for Group-B firms to harness their learning through external cooperation, and even got developed with further detailed contract editing. Chery also got well known for its cooperation with Bertone (Italy) on the bodywork design of Chery's *B21* model. Chery's delegate engineers refused to accept the output of Bertone for 3 times since the Italian side kept something relevant to development concealed. Bertone had to carry out the fourth round to communicate with the Chinese side and submit its output and report. It was the first time in Bertone's history to cost 4 rounds to finish a project.

7.3.3.2 Role of organisational learning system

In the cooperative projects, foreign sides would not forwardly point out the loci of new knowledge for Chinese partners. It was not only because of the interests of their sides, but also because of the differences regarding the contextual knowledge that each side had. The Chinese sides had to work out mechanism by themselves to obtain knowledge through the cooperation.

The first thing Group-B firms could learn from external cooperation was advanced technologies implemented by partners. However, beneficial technical information would not flow down to

Group-B firms' pool automatically. A series of organisational efforts were critical.

Beyond all, according to our interviews, representative engineers of Group-B firms were generally aware that their firms stressed the cooperation as an at least equally important process of knowledge acquisition as a process to outsource product or technology design. In fact, as a regular arrangement, delegate engineers of Group-B firms have to report to their home base inter-departmental team and their respective home departments not only the progress of projects, but also the new technologies they had learned from the cooperation. The collective aspiration of technological learning kept them sensitive to any thread to new knowledge.

In addition, they were authorised, and endowed with resources for further knowledge searching. Since much knowledge borne by international specialised firms was novel to Group-B firms in their early stages, Chinese delegates could not even expect what they could explore beforehand. In other words, searching new knowledge was a process full of uncertainty for learners in backward status. As both telecom-equipment and car were both complex technical and product systems, technologies usually highly interlinked with each other among different subsystems, components or disciplines. Engineers must be authorised to search or even to set up new projects with their external co-operators for further gains, since without doubt, these moves all cost resources. Particularly, the existences of many threads of knowledge were sensitive to the correlative time and locus; otherwise they would vanish from the processing tasks. It required the decision about further knowledge exploration to be made at soon as possible or even extemporaneously. Thus, Group-B firms usually endowed small quotas of additional resources for delegate teams. Certainly, official decisions for further exploration were more decisive, which could be made quickly by Group-B firms based on their abilities of organisational mobilisation.

The institutions of organisational mobilisation and learning integration of Group-B firms worked. In many cases, what delegate engineers could obtain from the external co-operators were just ideas, threads or fragments of new knowledge. It was usually far beyond the capabilities of the delegate team to draw out the whole elephant. Engineers at the home base must work the supporting roles to enable delegate engineers to explore new technologies further. Or even during the phase of knowledge identification, the inter-departmental home base force were already drawn in; after the delegate engineers got inspired through the cooperative projects, the information was transferred back to the home base and the major part of further exploration was practised by home engineers.

The facilities of knowledge accumulation were apparently important to construct the sensibility and absorptive capacity of delegate engineers, and then to enhance the interaction between the home base and delegate teams. For example, in case of an cooperative project of car-door development, delegate engineers could access the knowledge database of the home base either to study the corresponding knowledge accumulation about the car-door assemblies, or to get advices from multiple relevant departments (such as bodywork designers or engineers for systemic configuration) on the ongoing developmental object.

By contrast, in Group-A firms, even individual engineers could be incentivized to learn from foreign partners. However, their rigid organisational structure certainly could not realise the active on-site knowledge searching.

The second thing Group-B engineers could learn from foreign partners was the new method of development. The advanced methods were identified by the delegate engineers, but apparently the solidification and application of new methods must be achieved based on organisational collective efforts. For example, in HaFei's cooperation with Pininfarina, Chinese engineers found that Italian designers conducted the car configuration within the measuring cell from the very beginning. Before that, the testing cell, which consisted of a series of measuring instruments, was only used when designs had come to a relatively mature status. The new method was discovered to be better for the digitalisation of development in process, and then to promote the feasibility for other departments to share in-depth the information from very early on. This finding was reported to the home base. By inspiration, HaFei made a series of changes firstly entailing the product development and equipment departments. It also caused changes of the general schemes, including resource allocation, time scheduling of development procedures, and the data format of communications and task transfers, and so on.

In addition to act as the platform to facilitate knowledge search through external cooperative projects, the organisational learning system also worked as the filter of this kind learning activities by excluding incompatible learning. This function was actualised through internal conflicts and subsequent adjustments within Group-B firms. For example, in the Chery-AVL cooperation, the Chery side required to eliminate a series of frontier technical features in order to improve the robustness and manufacturability. This decision was made not only because of the preferences of local engineers who were involved in the development of these engines, but were also influenced by engineers from other departments. It was because in the name of advanced technologies and the consequent difficulties of discussion, AVL reduced the frequency of interactions with Chery's relevant home-based departments. It caused inconveniences and discontents of other relevant departments of Chery. In fact, the advocacies of AVL relating to frontier technological features had caused delays of the development of engines, then relevant assemblies and systemic car products. More importantly, the delays and the lack of communication brought about barriers to the in-house collective learning among different units. Thereby the relevant technological features and the correlative patterns were required to adjust.

7.3.4 Learning through interaction with customers

Learning from customers has been identified as important source of innovation, for example, learning from the lead users (von Hippel, 1988), and learning through the user-producer interaction (Rothwell, 1977; Lundvall, 1985, 1988). However, these viewpoints are mainly developed based on experience of industrially advanced countries, and stress the interaction between producers with leading or early users. Considering the reality that indigenous innovations in DCs may be not new worldwide in the pure technical sense, there is very possibly no leading users regarding particular technology implemented by Group-B firms to serve their customers, according to the definition of “leading users” developed by Abernathy and Utterback (1978) in their “product life cycles”. Therefore, whether the interaction with customers is still significant or not for knowledge creation of firms in DCs remains questionable.

However, based on our investigation, although Group-B firms had not mastered globally frontier technologies in their early phases, learning through interactions with customers was still critical for their knowledge creation. Between the two sectors we study, it was comparatively more significant in the telecom-equipment sector. The working conditions of telecom-equipment and the demands of users were often diversified and complicated. Therefore, for equipment providers, it was critical to stress these interactions to understand the needs of customers and the relations between the equipment systems with working conditions and the demands of telecom-users.

In Huawei, over 14,300 engineers were appointed to provide services for customers directly, while ZTE had 9,200 (data from 2007). Xinwei was still in its infancy with only 2,500 employees in total in 2006; but even its leading engineers also served customers directly. In other words, Xinwei had its forward customer service teams, home base project teams and specialised R&D departments overlapped, which imitated the strategies of Huawei and ZTE in inceptive stages.

Here, we stress that the new knowledge would not emerge automatically through the interaction between producer and customers. The creation of new knowledge entailed a process of problem identification, solution development and then knowledge accumulation, which obviously is a purposeful organisational process. So, rather than exploring what kind of knowledge is obtained from interaction with customers, we highlight the process of Group-B firms in identifying and developing solutions for problems discovered in the interaction with customers.

7.3.4.1 On-site knowledge searching and learning

Group-A firms hardly had space to learn from the interaction with customers even if individual engineers would like to do so. Because the products that Group-A firms provided for the market were technically developed exogenously, they did not have the rights, in terms of IPRs or technical confirmation, to make any significant change to the product systems, and did not have underlying capabilities to make remarkable design adjustments in-house. Their products were changed only over generations since the relevant decisions were made not to serve for the capability growth of Group-A firms, but to optimise the benefits of MNCs by utilising the product life of their models. Thereby, without trajectory-broken change as to the strategy of Group-A firms, there was seldom space for them to search for requirements and to determine product modifications in response to customer demands after their products had been launched.

Additionally, most Group-A firms had overlooked the interaction with customers in practice. The reasons might be complicated, partly because of the heritage of the command economy, and partly because of their (ever) long last incumbent market advantage. In the early years of Shanghai-Bell, it earned itself a bad reputation as a “sitting salesman”, which meant it never sent engineers to step out of its door to interact with customers. Regional telecom-operators had to make technical adjustments on their own if they wanted any service beyond the standard packaged functions. In fact, in early years, there were no fees recorded as for the improvement of product systems in productive Sino-foreign JVs. Now, as the top Group-A telecom-equipment firm, Shanghai-Bell was able to provide the customised solution of network construction. However, for its inability to change major products adopted in its solution, Shanghai-Bell had only very limited set of choices as to interacting with customers.

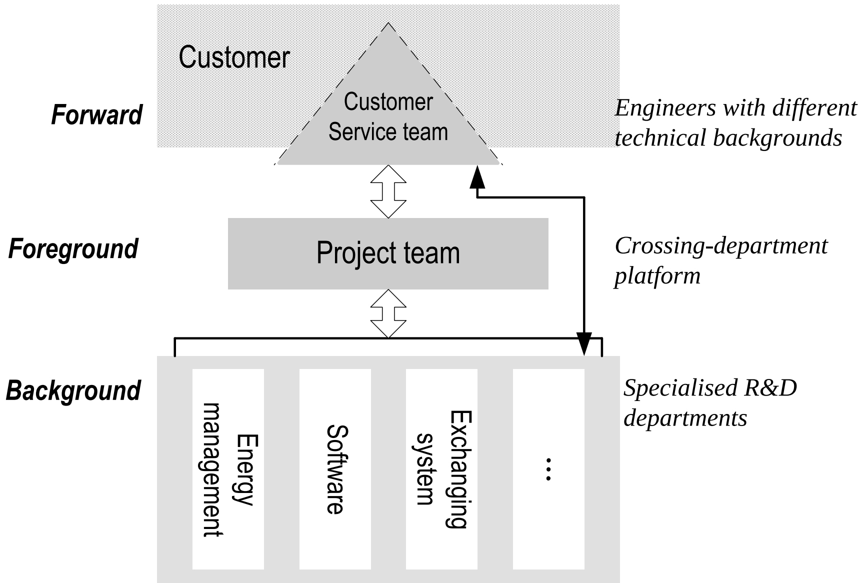
By contrast, Group-B firms had been investing significantly in customer services since their inceptive stages. In general, the activities of Group-B firms on interacting with customers could be categorized into two, namely to improve the existing product systems gradually and to develop solutions to serve the niche market.

In their early years, Group-B firms usually could not provide products with qualities as good as those of imports or Group-A firms, for which the difference came from not only process technologies, but also product designs and engineering. For instance, when Huawei provided equipment for its first important international customer, namely the Hutchnet in Hong Kong in 1996, the equipment Huawei provided was still unstable in performance. However, engineers of Huawei could answer any technical requests of its customer 24 hours a day and 7 days a week. They even slept in the machine rooms of Hutchnet in order to respond quickly to any problem. In doing so, engineers could even throw technical changes during off-peak times, mainly at midnight, which brought convenience for business operations of Hutchnet. Consequently, Huawei even invented an “online upgrading/adjustment” solution forwardly. Hence, the telecom service did not need to be suspended for most cases while the technical adjustments were in progress.

Providing fast response with flexible solutions to the customer demands was a distinct feature of Group-B telecom-equipment firms today either in the domestic or international market. For example, in 1998, an earthquake happening in Northeast China destroyed most telecom networks there. The service engineers of Huawei and ZTE arrived in the affected area in 24 hours. Ericsson had the largest market share with its GSM equipment in this area, but there was a long discussion within Ericsson-China first, about where the problem of system breakdown in earthquake resided in. Then not until two weeks later, Ericsson had not sent any engineer to the site. During this period, Group-B firms had finished technical maintenances of their equipment respectively. Moreover, Huawei even had provided some equipment for local operators to replace the network constructed by Ericsson temporarily. The point was after the service engineers of Ericsson arrived and did some checks, they informed the local telecom operators the system breakdown of their equipment was not their (service engineers) duty since apparently there was a designing weakness by overlooking the extreme working conditions, i.e. extremely cold, windy and, with earthquake. They gave their customers a telephone number, and informed the latter that customers were very much welcomed to report this technical problem to their product development division. Without surprise, the performance like this caused Ericsson a remarkable loss of market share in this area, which was mainly taken by Huawei.

As implied by the above case, the fast response was assured by organisational system rather than by individual engineers or customer service teams only. To supporting the service engineers, Group-B firms had to establish strong connection between their home base and forward teams (see the figure below). Partially, it was why Group-B firms employ so many R&D engineers and post-sale service engineers. In this way, the project team worked in the foreground while the in-house specialised R&D force worked in the background to provide support for the forward teams. Home base project teams kept real time communication with forward service teams. It meant if the service team worked at midnight, the corresponding project team would also be then ready to interact too. As the project team was built on cross-boundary inter-departmental platform, the multiple technical backgrounds of its members could help its forward team to figure out problems and develop solutions in many cases. For those exceptions, the project team could mobilise the specialised R&D departments. Moreover they also had the rights to communicate with relevant specialised departments directly in needs. Then the forward teams, foreground R&D force and background R&D force worked in an integrative manner for identifying problems, searching solutions, and fixing problems. Software adjustment and upgrading could be carried out on-line; hardware-relevant problems could be dealt with in a short time by producing new modules and replacing old ones, since the home base project team and the specialised R&D departments had already on the way. Meanwhile, the forward teams were authorised with necessary resources to carry out technical modifications on-site. Even for technological problems relevant to the product structure or multiple technological segments, changes could also be authorised to make by forward teams if they were needed to complete in real time.

Figure 7.2 Pattern of learning through interactions with customers



In the second place, serving niche markets was a "have-to-do" strategic decision for Group-B firms in their early years, since only these places were not penetrated by incumbents. Moreover, serving niche markets was also a distinct source of new knowledge creation for Group-B firms. Due to the lack of knowledge and human resource, customers in niche markets, such as telecom-operators in rural and remote areas, generally required special treatments, which brought about their potential requests of in-depth interaction with Group-B firms on equipment system and special technical solutions. Group-B firms even had to help their customers in developing business models, since their customers might have no idea what they could do with the new equipment they were going to buy. The special technical requirements also resided in complex working conditions. For example, there would be complex landforms in rural areas. In some cases, the charging system of telecom fees was complicated because of the irregular geographical boundaries. All these peculiarities induced Group-B firms to deepen their understandings on the technical and product systems.

In order to satisfy the requests of customers, forward teams of Group-B firms usually stayed near to the offices of regional telecom-operators for the conveniences to work closely with customers. There were many stories in this industry about how close Group-B firms cooperated with their customers. A representative one was like that: a new general manager of a county telecom-operator could not differentiate two Huawei's engineers from his own employees after he had already took the post for two months, because these Huawei engineers worked as active, positive and excellent as his employees in the machine room, at the counter and in field operations.

The "forward-foreground-background" structure was also utilised in response to the requests of customers in niche markets. Through learning from niche markets, Group-B firms would develop some special technologies in answering to some extreme conditions. These technologies might not be directly remarkable for common conditions, but their underlying knowledge revealed the in-depth internal relations and conflicts within the product systems, which were beneficial to the latecomer firms to deepening their understanding.

Xinwei's learning in serving the Daqing area was a typical case. Daqing was an oil-producing area in Northeast China. Since the oil plain was underpopulated, the BS (Base Station) systems were required to build with low density to save investments. Then, in order to promote the covering radius of each BS, the core parts of the BS system was expected to build on tops of high towers in general over 20 meters high. It brought about tough working conditions for the BS system especially in winter evenings, namely -40℃-60℃ with fierce winds, which had not been considered by equipment providers normally. Therefore, the original BS systems turned down automatically because most IC chips inside worked abnormally under the extreme conditions; and the feeder of smart antenna generated a 10° abnormal angle. In order to handle these problems, the local telecom-operator helped to provide full set of climate data for the past decades. Xinwei organised most of its elite engineers of all professional units to the site, since before correctly identifying the problems, engineers could not image what kinds of technologies would be entailed to solve the problems.

Based on the inter-discipline platform, engineers developed several rounds of solutions. For the sake of brevity, we just illustrate the first and the last solutions here. Initially, engineers thought it could be solved by promoting the air-conditioning system. However, under the extreme conditions, the temperature-adjusting effects were under control only in a very limited neighbourhood of the heater. The limits of energy supply were also problematic with this solution. The final solution was remarkable different. The air-conditioning just acted a supporting role, whereas the IC designers led the plan. The team decided to increase the power supply of the BS system, and increase the electric currents through it. But notice the current should be adjustable according to the temperature, which was achieved by an add-on module; otherwise, the system would be out of control again in summer. Relevantly, some modules were replaced in response to the change in rated electric currents. As to fixing the abnormal angle of the feeder, firstly engineers developed a simply electro- mechanical device to adjust it manually; Xinwei's service engineers did it from the machine room of telecom-operators at 2 am – 3 am in early morning. After several rounds' improvement, it came out with a special module, associated with the one above to control electric currents in respond to temperature, which could adjust automatically the feeder in real time.

We can categorise the knowledge accumulated through interactions with customers into the three types. Firstly, engineers could meet known problems, but in different ways or different range away from their previous knowledge. For example, the above case of Xinwei in fixing problems caused by extreme working conditions was a typical one. Group-B firms had to organise their in-house R&D force to identify the technical problem. If they could identify the technical problem, they ought to be able to figure out the solution by efforts to extend and re-organise their existing capabilities. The systemic understanding of the firms was critical to develop the problem identification and solution. When they were still in their early years and lack of sufficient systemic understanding, Group-B firms enhanced the inter-departmental support for forward teams to offset the weakness in systemic understanding of individual engineers.

Secondly, engineers would meet problems that were outside the scope of knowledge they had already possessed. For example, Xinwei's engineers ever met a particular situation: At the boundary of network, when one point of the network got down, namely a BS, the mobile terminals under its charge would be led by the system and the smart antenna to rush into neighbour BS systems automatically to request registration. It was set by designers as a good method under normal situation. However, if the number of requests was high in a very short moment, and if the number of neighbouring BS was only one (boundary condition), the requests might cause difficulties or even dead-loop of the neighbouring BS. It was a new problem to the industrial community. In the face of problems of this kind, to extend the systemic understanding of Group-B firms was primarily critical, only by which, problems could be identified correctively, and could solutions be developed. Group-B firms had to set up projects and organise in-house and forward teams with forces from different specialised units. Laboratory and on-site experiments were usually employed as the locus of inter-departmental communication.

Thirdly, engineers would develop new technical applications from the interactions with customers. Potential demands were identified by Group-B firms' engineers even when customers had not been conscious of them. For example, ZTE's experts in charge of the development of equipment for videoconference discovered a potential demands for the on-work group calls from their customers. Supported by the in-house digital mobile telecom division, they developed a GOTA (Global Open Trunking Architecture) system to serve the potential needs. It led the way in this segment globally, since at that time all foreign competitive products were still based on analogue modes. For such situations, forward engineers identified demands with their knowledge about product and technical systems. Relevant specialised forces were mobilised to realise the goal.

7.3.4.2 Role of organisational learning system

The role of the organisational learning system of Group-B firms in their learning practices based on the interactions with customers has been analysed by the "forward-foreground-background" metaphor. Additionally, the knowledge database worked as the physical working platforms of these activities, by which the negative effects caused by geographical distance were reduced and the integration of learning was promoted. Certainly, as the learning was based on cross-boundary inter-departmental platforms, the organisational learning system also worked as a learning filter, by which impractical solutions would be removed. Regarding the case of Xinwei's project to fixing the problem caused by extreme working conditions, engineers ever put forward a solution to add one heating panel to cover the motherboard inside the BS. It was a good idea to solve the problem caused by low temperatures. However, such a heating panel would influence the electromagnetic field within the system. If more modules were introduced to balance the electromagnetic field, the relevant designs would turn to be highly sophisticated. Thus, the idea was denied when it went to engineer experts in systemic configuration.

7.4 Analysis

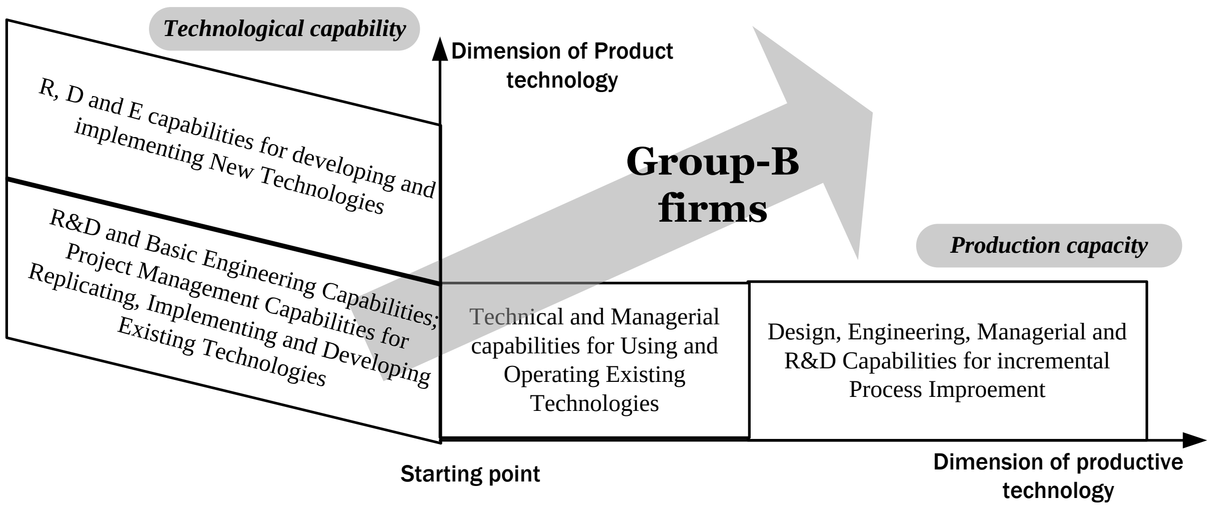
By this chapter, we have exhibited that three essential mechanisms of knowledge creation were closely buttressed by the organisational systems of Group-B firms. To complete the chapters concentrating on the empirical comparison between the two groups of firms, we would like to stress two points. First is a classical topic, namely the learning sequence or the trajectory of capability-building of DC firms. Second is about the ongoing change of Group-B firms.

7.4.1 Learning sequence of Group-B firms

In this thesis, by centring our discussion on organisations and organisational processes of technological learning, we get the impression that there is no distinct watershed between different stages of capability-building if the stages are defined by real capability-building, such as the capability-building of product development, the capability-building of equipment development, etc. Although the strategy making and the activities implementation can be executed stage by stage in a distinct manner, capability-building is always based on a trade-off between the localised learning and the heterogeneous information searching. As the foundation of learning implementation, the cross-boundary inter-departmental platforms of Group-B firms define that the intellectual objects to be learned at the centre stage of collective learning must be understandable to relevant participant units. During the learning process, the individual learners of latecomer firms, from different but relevant units, have to realise knowledge sharing, mutual understanding and consequent adjustments. Then what kind of threads are to be drawn in knowledge creation processes, to some extent, is an organisational question rather than a pure technical or resource-based question. In other words, as we said, the organisational system and the existing in-house knowledge base work as both the platform to facilitate technological learning and the platform to filter knowledge creation. Thereby, the knowledge output of their interactive activities would not show up with disruptiveness at micro level, although their embodiment as artefacts (i.e. the technologies or products) can demonstrate with disruptive changes. Certainly, from the perspective of system, the singular points exist. When the singular points are attained, the organisations would experience rapid systemic growth of knowledge as usually we say some are inspired. However, the rapid growth of in-house knowledge is still obliged to be grounded on gradual organisational learning and interaction, coupling with the hierarchy of knowledge. During the course of knowledge growth, the accumulated knowledge is added to the existing knowledge base, and becomes part of necessary foundation for further knowledge creation.

Regarding the ladders in describing the “capability growth” according to major technologies or activities that firms implement, we argue that there is not a fixed sequence for all catching-up firms. For each firm, there can be different contextual conditions for the starting-up and growth of firms. Even only referring to the cases drawn in this thesis, some firms could start from significant technical breakthrough (*HJD* series and the SCDMA of Xinwei), while many just stayed with manufacturing and assembling. If we are asked to illustrate such a ladder for most Group-B firms in our investigation only (except for Xinwei), we would stress that, by comparing conventional ladders, Group-B firms had not been obliged to establish absolutely sufficient production capacity before they entered the stage of development of products and complex product technologies. Certainly, such kinds of arguments are reasonable that some capabilities of production had been accumulated and embedded in the domestic industrial community before Group-B firms started their journeys. However, it is still remarkable that Group-B firms had not figured out all necessary processing technologies prior to they launched their inceptive products developed in-house. They established inceptive bases of technological capability simultaneously along with building their earliest production capacities. In other words, in their early stages, they had already mastered the capability to generate and manage technological change. After that, the exploration and accumulation of technological capability had never been ceased to date (see the figure below).

Figure 7.3 Ladder of technological capability growth



Nevertheless, as we stressed, there is no common sequence of capability-building for all catching-up firms. Even suppose that the conventional ladders in literature do correctly demonstrate the practical capability-building sequences of the objects of corresponding research. The difference of our ladder from most conventional ladders reflects the diversification of potential emergences in terms of technological catching-up of DC firms, which follows relatively simple principles of interactions as the relations between technological hierarchy, resource (and business) constraints, individual learning and organisational systems.

7.4.2 Current changes of Group-B firms

The priority of specific organisational learning systems is not what we buttress for all stages of capability-building during catching-up. Rather, in this thesis, what we present is how Group-B firms organised their in-house forces to realise learning tasks identified by them in particular stages. Therefore, we imply that, in the face of different tasks, Group-B firms should adjust their organisational systems for better learning performances. However, questions would turn to be how Group-B firms should change and whether they could change effectively.

In fact, the leading Group-B firms do have the trend to stress regular patterns of interactions between different specialised units, and stress the benefits from professionalization more than before. Certainly, the cross-boundary inter-departmental platforms are still in the spotlights of the process of product and technology development in Group-B firms. However, the responsibilities of each participant unit that could be manifested as quantity (e.g. time consuming and scale of task) and quality (e.g. technical level, resource consuming and on time) of development get better defined. Not every developmental detail is encouraged to place on cross-boundary platforms, such as the well-defined duties of specific units. Such a change is driven by the growth of in-house knowledge accumulation in specialised segments. Besides, the increase of collective understandings about products or even industrial systems shares at least the equally importance in driving the change. In the name of integrative knowledge, such understandings are embodied in their organisational structures, their rules of development organising, their databases of technological information, the experiences of their leading engineers and the basic cognitions borne by active junior members. With these conditions, through stressing the professionalization and regular patterns of interaction, Group-B firms can promote the efficiency of developmental activities.

Huawei was the first one among Group-B firms to experiment such a change. Starting from 1998, with the assistance of IBM's consultant service, Huawei began to construct its IPD (integrated product development) system. Chery is an ongoing case to enforce a governance change. From 2007 on, it aims to confine the irregular personal and material flow between different units. As observers, we cannot predict accurately where Group-B firms will finally go after the current transitional stage. However, we shall note that the fundamental features we stress of organisational learning systems of Group-B firms in this thesis have not been removed from centre stage yet.

Chapter 8. Discussion: technological learning and changes of organisational systems

8.1 Introduction

The difference of organisations is an essential feature of firms under competitive environments (Nelson, 1991). Certainly, the organisational systems are nominally selected by firms only if they have managerial autonomies. However when organisational differences emerge as group-specific characteristics among different groups of firms, they cannot be explained as natural features of firms. Rather, such a situation implies connections of social conditions to organisational systems of firms. In our study, as the practitioners in DCs generally lacked experience to implement successful technological capability building at the starting points of their journeys, the DC firms we studied in fact were unable to select learning patterns freely from a wide range of choices. Their perceptions of neighbouring information constrained the development of their understanding about technological learning. So in addition to their original intent, firms could be collectively influenced by some external advocacies, or they might forwardly imitate the practices of some first-movers if the first-movers were identified as exemplars by them. Moreover, the relations among different organisational members within firms were also influenced by the relevant societal relations. Then there come the theoretical significance to study the source and process of different choices of firms in their journeys to generate better understanding about organisational construction and learning.

Similarly, readers would also feel puzzle. As the organisational learning system is so important, why could not be solved by encouraging other firms to copy the experience of successful organisations in detailed. The answer to this question is from the same root of social foundation of different organisational patterns. Jointly affected by a series of political, economic and culture factors, and with its essential inertia, the social cognition is not flexible to change. First-movers who bear the risks related to not only the technological dimension but also the organisational dimension are necessary to cause significant social changes.

The social-economic circumstances, which were as backgrounds to the development of the two groups of Chinese firms, are discussed in this chapter. After that we also give a revisit to the theories we ever noted to frame our study.

8.2 Historical revisit: organisational revolution in China's industries

Any real organisation would have developed a highly elaborated set of understanding about control, which could be represented as the informational requirements and social requirements (Ouchi, 1979, p837). However, regarding successfully technological catching-up, either the government or firms have to search and establish their knowledge through practices, by which we say they are not omniscient. The process that China explored effective patterns for rapid development in the past 6 decades proves this point.

Essentially, in order to achieve the organisational mobilisation and learning integration, front-line engineers not only require relevant resources allocated for the appointed tasks, but also require resources to be allocated reasonably and implemented according to their understanding and needs about the technological aims in process. With Nonaka and Konono's term (1998), resources should be manipulated within the "*Ba*" of knowledge creation. Since knowledge creation resides in the individuals' learning and their integration, the strategic resources obviously should be manipulated, at least at tactic level, by communities of engineers who are to share common knowledge and to solve the problems. Relevantly, the authority to identify and figure out some emergent problems during the practical development process is expected by front-line engineers. Certainly, in practices, managers would not definitely agree on this point. Then it leads to a question about the social relationship within enterprises, as how the authority (and consequently resources) is distributed among people at different levels within the firm.

In the 1950s, the Chinese industrial community established patterns by imitating those of USSR, which were similar to those based on the advocacy of Chinese government after the early 1980s with the TMFT framework. Learning activities were heavily framed by the upper-level organisation or followed the foreign technical sources (experts or importing blueprints). Even in the interval between these two periods, development tasks were also kept away from front-line engineers of productive firms largely, and implemented by governmental R&D divisions. Therefore, engineers in productive firms were kept far away from the authority distribution for specific resources manipulation in most cases.

However, we must not overlook there were controversies among policy-makers and industrial practitioners on this topic in the past decades. From the late 1950s, a movement represented by the "*AnGang Constitution*" was raised, by which some authorities on resource manipulation were distributed to front-line engineers. However, for economic and political reasons, the new pattern was kept with debates. Its residues were cleaned up through the erection of TMFT and the reformation of SOEs: the TMFT framework induced domestic firms to follow existing external technical schemes; the reformation of SOEs imposed more centralisation of authority to the factory heads and managers within firms. They deepened the gap between managerial authority and front-line personnel as regards the resources manipulation. Later, the emergence of Group-B firms presented semi-subversion to the previous pattern. We term it as semi-subversion because the changes raised by Group-B firms had not covered the entire organisations (such as the workshop in general). But Group-B firms denied the previous *Fordist* patterns of resource manipulation within the product and technology development division. Engineers were endowed with some authorities on resource manipulations, which was the substantial organisational foundation for the new organising pattern of learning of Group-B firms.

Therefore, we open a new perspective. In Chapter 4, we pointed out the pathway choosing of policy-makers and industrial leaders regarding the patterns of technological learning and catching-up. Here we aim to place them in a broader socio-political process. Sure, to explore the social foundations about the evolution of Chinese industrial firms requires in-depth investigation relevant to the social, political and economic changes, which is not our goal in this chapter. Here, we just present some critical connections of social foundations to the organisational learning systems of firms, which would help to enhance our understanding about the couple of organisation and technological learning by contrast with any resource-based view.

8.2.1 Evolution of social relations within China's industrial enterprises

8.2.1.1 Before the 1970s: Magnitogorsk Constitution vs. AnGang Constitution

In the inceptive years of PRC, a quasi craft control system was broadly implemented in industries. Front-line workers and technicians were controlled by gangs and foremen. After communists won the national power, they carried out reforms to get rid of the vested foremen class, and provided a series of welfare to replace the services provided by gangs and foremen (F. Lu, 1999, 2000).

The new industrialisation of China after 1949 was started with the cooperative projects between China and USSR and other communist countries. Thus, the management patterns of industrial firms in China were built through the imitation of USSR factories (Kaple, 1994), which could be summarized as the "*Magnitogorsk Constitution*" (the management pattern of Magnitogorsk Steel Mill) that was advocated by USSR to spread among communist countries. The Magnitogorsk pattern could be regarded as a modified version of *Fordism* under the socialist environments (Beissinger, 1988). The Magnitogorsk Steel Mill itself "*was modelled on the United States Steel plant in Gary, Indiana; and the Gorky Automobile Factory was built by engineers and workers from Ford and modelled on the River Rouge plant in Detroit, at that time considered the most modern of its kind in the world*" (Josephson, 1995, P528). The *"mandatory plan system*" and the "*single-head system*" were the key features of the Magnitogorsk pattern (Cui, 1996). The mandatory plan system framed the basic structure of the economy, and the single-head system was the method used to manage each economic units. The single-head system was usually termed as the "*expert responsibility system*" by its advocators, which meant the factories were set in a centralised manner ruled by one or just a few industrial experts, not by the front-line proletariat. Most members of organisations were expected to act under the frameworks that had been well set. These institutions upheld the foundation of USSR's industrial system to be rigid, centralised, top-down, politics-based (von Tunzelmann, 1995, p286).

The *Magnitogorsk Constitution* was spread in China along with USSR involved cooperative projects. Soviet experts, some Chinese policy-makers and industrial leaders obliged Chinese firms to duplicate the Soviet experience. USSR provided thousands of books about industrial management and planning for Chinese practitioners (Kaple, 1994). For example, FAW, at least its truck division, was the "*copy*" of the Stalin Automotive Factory both in physical and social technologies. Even since the Soviet sample did not have a department of product development, the FAW had it neither before the late 1970s.

However, front-line practitioners in some firms witnessed that the rigid duplication of well-schemed procedures and management patterns did not lead to performance as good as expected. Reasons could be various, but one of them was substantially related to the skill control. Although the USSR provided China some equipment, blueprints and experts through the cooperative projects, automatic production lines were still not popular even in the national key factories of China, and the average degree of automation was low, which contrasted with the situations in USSR. In reference to the core equipment in Chinese firms, many of them were backward, based on manual operation, and came from different sources so were not standardised to each other. Under such circumstances, personal skills and operational habits were critical as to promoting the productivities and inducing innovations. Even in the late 1980s, the delegation of Volkswagen still noticed that some procedures in Chinese backbone SOEs still relied on personal skills, "*…(in the metal casting workshop of FAW) a worker had to stand on a heightened platform, caught the containers with liquid steel inside that was carried by the rope gearing instrument manufactured by Demag (Germany). He had to hold the switch at the lower end of the rope, which was a dangerous acrobat moment of life or death…operated the mental casting…* (Hahn, 2005, p133-134)". So, the critical skills in Chinese industrial firms in practice were not fully controlled by upper managers as in the *Fordist* system.

Then, back in the 1950s, innovations about the organisational learning system was still developed initiatively by some Chinese practitioners. The Anshan Steel Mill ("AnGang" in spoken Chinese) might not be the first one to do so, but was regarded as the representative in this tide for the significance of its innovation, and also for some political reasons.

AnGang was a factory partly built with the aids of USSR, and was the backbone force of the new China in steel making. The management innovation in question was initiated in a bottom-up manner by front-line practitioners, with at least three reasons. Firstly, front-line practitioners did not agree with the *Magnitogorsk Constitution*. The equipped machines that AnGang used were from divergent sources. For example, as for the bloomer factories, without mentioning the supportive machines, there were bloomers provided by Krupp (Germany), which was imported by

Japanese invaders during the puppet Manchuria regime; there were also bloomers produced by Ural Heavy Industry (i.e. the equipment provider of Magnitogorsk Steel Mill), which were bought as advised by Soviet experts. If people wanted to promote the productivity of bloomer mills, a series of overpressure experiments were needed for each bloomer respectively as critical procedure to gain necessary technical information. However, Soviet experts insisted on existing operational manuals brought from USSR rather than allowing on-site experiments. It caused conflicts between the local front-line practitioners and people following the Soviet authority. Secondly, the institution of *single-head system* was brought into AnGang by Soviet experts; besides, based on the similarity of life habits, a distinct cultural clique was formed by Soviet experts, Chinese returnees from USSR and some higher rank cadres. It caused oppositions between the upper clique and lower organisation and some "local-oriented" managers. Thirdly, most common people were still inspired by the enthusiasm originating from the birth of the new China. They were eager to explore new things beneficial to the collective and national interests in spite of the office politics.

Then, a revolution, which in fact was a rebellion against the *Magnitogorsk Constitution*, occurred in AnGang in 1958. With the support of an enlightened head of the No.2 Bloomer Mill, front-line practitioners did the experiments by themselves, and made successful improvement. The capacity of the Ural bloomer in the No.2 Bloomer Mill was increased from 1,800,000 to 3,200,000 ton/year (crude steel). It was an amazing achievement that benefited the mill for 3 decades, as the capacity had never been successfully increased so remarkably again since then. The "d*ouble ingot rolling*" and the "*7-pair experiences*" were summarised as outcome of physical technologies from the innovation. As the other local practitioners got inspired, relevant innovations, both in terms of organisational change and technological change, were carried out in all over 180 mills or equally units in AnGang.

At that time, led by Chairman MAO Zedong, Chinese government partially supported the decentralisation of economic control. Up to the end of 1958, the control of 87% MOEs were decentralised to regional governments, or even to the administration of streets or communities. The decision-making powers of resource allocation and price-making were also decentralised to some extent. These changes, as the social cognition change against the previous highly centralised mode, inspired the bottom-up reformation within enterprises. Generic revolutions similar to that happened in AnGang occurred within SOEs gradually around over China.

From 1958, the experience about learning organising of AnGang's innovation was formulated into the "*two-participation, one-modification, and three-integration".* The "*two-participation*" meant managers and cadres should participate in front-line physical works in their spare time; technical personnel and workers had rights to participate in management by regular institutional arrangements. The "*one-modification*" meant to remove the inappropriate institutional arrangements, which in fact legalised the organisational innovation against the *Magnitogorsk Constitution*. The "*three-integration*" obliged integrations among managers, technical personnel and workers. In other words, it inspired the economic democracy, by which engineers and workers were allowed to advise management changes and had channels to share the authority about resource allocation.

The experience of AnGang was named as *AnGang Constitution* in 1960 by MAO. In fact, the "*AnGang Constitution"* was in line with MAO's thoughts, which were negative regarding the emerging privilege class and bureaucracy. Readers should note that the Sino-Soviet split was ignited during 1959-1960. MAO praised the *AnGang Constitution* as an innovation belonging to the people not merely in China but in the entire Fareast. It exhibited MAO's advocacy of "*economic democracy*" against the "*single-head system*" of the *Magnitogorsk Constitution*, and the *Fordism* sitting behind them (Cui, 1996, p20).

The whole country was mobilised to study the *AnGang Constitution* and relevant experience. Associated with it was the "*Great Leap Forward*" (1958-1960), by which people were encouraged to try all kinds of inventions, although some came out to be ineffective. Even though it was evaluated by Chinese official today as mistake, ironically, many indigenous product designs held by Group-A firms till to the 1980s did originate from this movement. If take the car-making sector as an example, we ought to refer to "most" rather than "many", since such a list included the *RedFlag* (inherited from the *DongFeng* model developed in 1958) of FAW, the *JingGangShan*, the *Beijing* and the *DongFangHong* models of Beijing Auto, three *Phoenix* models (the precursor of *Shanghai*) of Shanghai Auto, and so on. So some domestic industrial practitioners consider the year 1958 as the birth of the indigenous car industry (Zhao, 2006).

Behind the emergence of these product designs was the reform of social relations within enterprises in the name of *economic democracy*. Front-line practitioners were authorised with greater access to strategic resources for production procedures, technical exploration and product development. The integration of managers, engineers and workers brought about cohesion of their organisations for collective goals of development. Therefore, some scholars take it and the relevant ideas of MAO as early thoughts of TQM (Thomas, 1994, p209) and *Post-Fordism* (Cui, 1995). Koaru Iskikawa, one of the founders of the Japanese TQM system, also said publicly in a conference in 1978 that the first TQM group of Japan formed in May of 1962 had benefited much from the 1958-version *AnGang Constitution* (Zhu, 1997).

However, the *AnGang Constitution* had not been continuously encouraged officially. In the practical operation, the diffusion of *AnGang Constitution* was bound to the *Great Leap Forward*. The *Great Leap Forward* went into a remarkable failure. Quite a few factors jointly worked, including the cost-regardless expansion in the steel industry, the inflated exaggeration of the governmental system in the agriculture sector, the natural calamities and the pressure to pay USSR for the support in Korean War and cooperative projects. These factors finally resulted in a well-known famine. Since the *Great Leap Forward* was taken as a mistake and ended, the *AnGang Constitution* was also criticised by its opponents. For some cases, the application of *AnGang Constitution* did get deviated from its original thoughts: people required upper managers to work with workers in front lines regularly, not in their spare time; workers interfered in the management directly without strict limitations. In same case, the *AnGang Constitution* was intentionally introduced to drive some change with political reasons, rather than to improve the economic performances.

The central government ceased the *Great Leap Forward*. A remedy plan termed as "*70 items of SOE regulation*" was launched in 1961 to rectify the economic order, and to cease the industrial community from being actively mobilised. DENG Xiaoping played a leading role as an assistant to Chairman LIU Shaoqi in the remedy plan and the "*three years of economic adjustment*" during 1963-1965 [131]. In 1964, articles appeared in Chinese newspapers urging greater product specialization. Even though the moderate tone of these articles indicated no forcible return to Soviet methods (Schurmann, 1968, p299), the official diffusion of the *AnGang Constitution* was stopped at this time. Deng and his colleagues stressed the piece-wage, time-wage and the post responsibility systems against the organisational mobilisation. In other words, the social relations within the enterprises were changed back.

8.2.1.2 After the 1970s: economic reform

After 1971, the domestic industrial community gradually recovered from the severe turmoil that began in 1966, namely the "*Culture Revolution*", although to appease the political struggle still required several years. In 1971, China resumed communications with the United States, followed by the "*43 Arrangements*" and "*78 plan*" to import foreign technologies. But since equity-based cooperation were not included, the management systems of Chinese industrial firms were still influenced by domestic force mainly, in fact as mixed, jointly influenced by the tradition of *Magnitogorsk Constitution* and the *AnGang Constitution.*

At the end of 1978, DENG was upheld by his comrades to be the actual core of Chinese authority. This political change brought about a shift in the patterns of utilising foreign technologies that the equity-based method got green light gradually. DENG and his colleagues carried out the economic reform from 1978, which was also inherited by his successors. Here, we highlight several points

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[131] Deng was an opponent to the *AnGang Constitution*. In a letter DENG wrote to MAO in 1972, he articulated his previous deviation from the '*AnGang Constitution*' (DENG Xiaoping: the letter to Mao Zedong, 1972-08-02).

directly relevant to the social relations within enterprises.

In 1982, a "*factory director responsibility system*" was started, by which the heads of SOEs were given with autonomies of operational management, particularly those to allocate personnel and resources for productive activities. The labour contract system was introduced to take the place of the political-based lifetime employment primarily for the lower level organisational members. Then, with different treatments, the authority and responsibility on SOEs were primarily entrusted to upper managers, not lower level of organisations. In fact, during the reform, upper managers in most cases had more "discourse power" by contrast with the lower level. For example, in 1984, 55 factory heads signed jointly to request further management autonomy as an extension to the "*factory director responsibility system*"; subsequently in 1985 they did win the autonomy in managing the incentive system. By contrast, the lower level organisation was generally regarded as the source of the ineffectiveness of managerial control and the unsatisfactory productivity.

During 1986-1992, the "*enterprise contract management responsibility system*" was prevalent. Not only the SOEs, but also their subordinate units, e.g. workshops, teams and groups, could be contracted to particular persons. Contractors had super authority over the operational activities within their contracting ranges. It actually recovered the "*single-head system*" within firms. In such a system, as the critical tasks were well defined by the contractors both in directions and in details in order to protect their own benefits, the responsibility of the low-level organisation was further and heavily depressed.

In 1993, the shareholding reform of SOEs was started in the name of governance modernisation. It actually legalised the control of a few upper managers as in the previous period over the relevant firms. In some cases, common employees were offered with options to buy share stocks with specific quotas. However, in the face of the fading of previous welfare system that was under reform as an accessory of the "old-fashion" central planning system, most common workers did not have the purchasing power. Their shares on hand were too small to have real voices over the decision-making. Besides in China after 1949, there was no actual workers union in addition to the one organised by the government and corporate officials as a decoration. The shares of workers, even also small in the aggregate usually, were seldom gathered by effective leadership to impose the rights on decision-making of firms. Therefore, the shareholding reform in practice enhanced and legalised the power of individuals or cliques with large shares in hand who in many cases were leaders of these firms and had purchasing powers. Certainly, there were still some public shares held by the government nominally. However, the real executors of the public shares were absent at that time. Even in case governmental agents (such as the SASAC system after 2003) did work later[132], the governmental agents cared only the maintenance and increasing of asset values, and let the social relations or even production process within SOEs untouched. Besides, in light of optimising the governance of SOEs, further reforms were carried on in the second half of 1990s, which solidified the absolute authority of major shareholders. During this tide, governmental shares receded from SOEs heavily, which was a practical process of privatization.

Besides, by issuing the laws that favoured FFEs regarding tax treatments, Chinese government intentionally encouraged general SOEs in addition to those involved in TMFT framework to introduce FDIs as a method to modernise their corporate governance since 1991. Only for the Wuhan City in 1994, there were 816 SOEs that carried out equity-based cooperation with MNCs (D. Zhang, 2006). We do not mean to deny good aspects that MNCs contributed to Chinese industrial community here; but most Sino-foreign productive JVs were only regarded as pure manufacturing divisions of MNCs' global value networks during 1980s-1990s. Moreover, even though many Sino-foreign productive JVs were in the name of adopting advanced patterns such as the "*Lean Production*" and the "*Post-Fordism*", what they brought for Chinese industrial practitioners in most cases were the exhibiting rules as the outcome of these advanced patterns. As Thomas (1994, p209) comments, there could be two ways to incorporate "advanced patterns". One is consistent with the broad philosophy that the corresponding pattern advocates, and is to mobilise the organisation for continuous improvement and learning at both individual and collective levels. Meanwhile, the other solidifies the organisation to learn the rules exogenously generated by these patterns and prevent changes within the organisations.

8.2.1.3 Summary

From the 1950s on, the China's authority and its industrial community continually endeavoured to develop appropriate patterns to realise rapid industrialisation. Their thoughts and the process were full of ambiguities, conflicts and controversies. Policy-makers and industrial practitioners did not have clear and confirmed knowledge about what types of patterns were better for Chinese. Rather, they had to explore relevant "social technologies" through practices.

"*AnGang Constitution*" presented the bottom-up efforts of its kind to realise the mobilisation of organisation to achieve better quality of technological learning, and was also a movement against the emerging bureaucracy and quasi bureaucracy within enterprises that rigidified authority to the fixed and a handful of persons in the economic life, which was meaningful especially under the configuration of socialism. The economic reform carried out in China since 1978 actually drove the mainstream of Chinese industrial sector back to a pattern similar to the *Fordism* rather than the

[132] For example, Qian (2001) argues that the governmental direct control over backbone SOEs was enhanced again after 1994 by the erection of the precursors of SASAC

Post-Fordism, which connects our main story with the emergence of Group-A firms. The mobilisation of front-line practitioners was not encouraged by policy-makers or higher authority within enterprises. The lower level organisational members had little bargaining power to maintain or recover their social status within enterprises as before, such as by the "*AnGang Constitution*". The reform was deepened step by step, and the status of front-line practitioners turned to be similar with what described by Piore and Sabel (1984, p113) on the United States model of mass production that their job was "*a precisely defined aggregate of well-specified tasks*". They lost the authority, and the responsibility, to deal with the definition and classification of tasks, namely to carry out spontaneous technological learning under an organisational framework. In the light of adopting advanced patterns, the contents that they were asked to learn might come from *Post-Fordism* patterns, but the contents were just the written rules that had been developed exogenously somewhere else, by which they were forbidden rather than being mobilised for changes.

Some scholars might have different views. For example, Chan (1995) adopts the framework of Dore (1973; 1987, p29-31), and implies that the Chinese pattern of industrial firms will converge with the Japanese model, namely the organisation-oriented system, more than the market-oriented system prevalent in Britain and American. He takes the legacy of "Maoist model", such as the iron-bowl and the self-identities of workers to underpin his argument. However, he neglects that the legacy could not last long without support of practices. In fact, as the lower-level organisation seldom had institutional powers to contest for the authority within enterprises, the disadvantageous situation of them during the reform was presented by the continuous privatisation of SOEs and the mass *XiaGang*[133] in the late 1990s.

The ailing situation of lower level organisation was even maintained after the mass *XiaGang*. For instance, up to 2006, the wage levels of front-line practitioners in the truck division of FAW and the FAW Car Co. had not been increased for any since 1998 while during this period the annual production output of FAW had increased from 300,000 sets to 1,000,000 sets. Considering that the firm implemented the piece-wage, the actual nominal wage levels were in fact demoted even without considering the inflation. As contrast, high level and some middle level managers enjoyed income growth as 2-8 times than theirs in 1998 (data from 2006). Even though the FAW kept efforts to incorporate the Japanese patterns, it was hardly to image how the lower level

[133] *XiaGang* is a special word in China for describing the unemployment situation of employees of SOEs. Literally, *XiaGang* means the person is only off from the working position. He/she would have just little or even none pension for such a status. However, in fact, most *XiaGang* employees could not go back to their previous working positions or their previous enterprises as implied by this concept literally. Thus, some scholars regard *XiaGang* as the status of actually unemployed. There is no specific accurate data for the scale of *XiaGang* in the late 1990s. But the number is broadly estimated from 22- 30 million. Through *XiaGang*, many SOEs were closed, reformed with stock-holding scheme, or sold to the private sector.

organisation with a continuously demoted status could actively participate in the realisation of TQM, JIT and flexible production, as considering their motivations and authority. As for the general situation in China, the ratio of labourer remuneration to GDP decreased continuously from the 56.5% in 1983 to 36.7% in 2005.[134]

Only after the emergence of Group-B firms, could a new model be recognised. And such a process is still ongoing.

8.2.2 Change of managerial autonomy and organisational learning system

In a transition country, the previous institutional settings, which were distinct to those of mature market economies, usually contained the sources of its economic and management problems. The lack of managerial autonomy of Chinese firms in the previous era, as explained such as by the principal-agent theory, is broadly regarded as the source of difficulties of them regarding technological learning at that time. Q. Lu (Q. Lu, 2000; Q. Lu, and Lazonick, 2001) focuses on the relation between the change in corporate governance and the emergence of Chinese indigenous innovative firms, and concludes that the three aspects of corporate governance, namely the management autonomy, the commitment to technological learning and the balanced incentive system, are requisite conditions for Chinese indigenous innovative firms.

It is reasonable that without managerial autonomies, firms are difficult to generate innovations sustainably as they have to respond to uncertainties associated with developmental activities under the competitive circumstance. However, it is necessary to consider whether the three aspects are sufficient. The evolution of Chinese industries imposes a negative answer. In 1994 only, at least 33,000 firms around China had already realised the shareholding-oriented reform, and over 4,300 reformed SOEs had updated their registration with the administration according to the new “corporate law” that compelled the separation between governmental intervention and enterprise governance. However, most of them had not grown up to be innovative, without considering the much more followers after 1994. Otherwise, we should suppose that these firms, large in number, all suffered from insufficient managerial skills and motivation for innovation; but it is apparently unreasonable. For example, the case of Lenovo, namely a firm included in the research of Q. Lu (2000) as a representative innovative firm, support our questioning. Around 1994, its director won a critical controversy over its chief engineer, and guided Lenovo to change since 1998 from a technology-oriented firm that stressed the development of ASIC chips to a production-oriented firm that stressed the manufacturing of personal computer. Lying behind the

[134] According to the spokesperson of All-China Federation of Trade Unions, source: http://news.sina.com.cn/c/2010-05-12/024420251101.shtml (last accessed date: 2010-06-09)

shift of capability-building path was an underlying change of organisational learning system: the team of systemic product development was moved from the foreground of business to the background, and later was reduced into a small unit for basic research. The management autonomy, the financial commitment and the growing financial capacity had not guaranteed of its persistence on intensive technological learning as before, even without mentioning the perfect or sufficient knowledge about the construction of organisational learning system for building innovative capabilities. Otherwise most Group-A firms in our study should have already been successful in in-house product development with their initial commitments and well-reformed "modernised" corporate governance patterns, so should Brilliant Auto before its major change.

Rather, our empirical study presents us an interesting case that, even with imperfect managerial autonomy, HaFei was still able to learn sustainably and efficiently. Because of its quasi-military status, its executive managers could hardly handle the incentive system without constraints. executives were obliged to keep every member on board, and the performance pay was very cautious to utilise. Therefore, in HaFei, the seniority of payment system remained largely at least up to recent years. A good-performing product development engineers with big contributions to the firm would not certainly get better pay than a front line senior worker did. However, although executives had no free choice to improve this, HaFei still progressed steadily for in-house learning.

The studies of F. Lu (1999, 2000) go further as for the relation between the reform of SOEs and their competitiveness. He stresses on the cohesive managers, managerial control over production process and new social relations within the enterprises. However, we still need to answer: what kinds of organisational patterns should be developed based on the social relations within enterprises considering their particular learning targets? And how could core members obtain relevant knowledge to realise the relevant organisational construction or transition?

8.2.3 Organisational revolution and bandwagon effects

In modern industrial economies, especially those undergoing fast development, the large firm performs its critical role in the evolution of industries not merely as a unit carrying out transactions on the basis of information flows, but, more importantly, as a creator and repository of product-specific embedded organisational knowledge (Chandler, Hikino and von Nordenflycht, 2001, p2). The progress of the SOE reforms and the TMFT framework had caused significant influences on the evolution of other domestic firms. Later, as the heterodoxy to Group-A firms, the successes of Group-B firms in developing indigenous product platforms and realising commercial survival, again, are followed by many domestic firms.

8.2.3.1 Emergence of Group-B firms

Group-B firms were engaged in the tide of reform aiming at corporate modernisation, so the managerial control within Group-B firms was assured by the contract-based employment system. However, Group-B firms have developed internal social relations different from other domestic firms, by which upper managers do not supervise the development activities of front-line practitioners by details. Rather, resources are authorised to developers under a set of institutional arrangements to deal with detailed knowledge search, generation, accumulation and diffusion. To be specific, within some basic management framework, developers are legitimised with the "autonomy of learning". REN summaries this pattern of recourse authorisation and technological learning in Huawei as "*Let the people who can hear the thunder of guns make the decisions (of resource distribution)*[135]." Only with the authorisation of resource application and learning autonomy, can front-line practitioners implement learning according to the endogenous technological logics, the associated uncertainties, and the relevant coordination for technological and organisational integration. Key features of organisational learning systems of Group-B firms, such as the cross-boundary inter-departmental platforms, the comprehensive knowledge databases and relevant supportive institutions, including intensive interaction and on-site problem solving which engage multi-department actors are feasible only based on such kind of social relations.

So by contrast with other numberless domestic firms that failed in searching for appropriate patterns for rapid technological catching-up, Group-B firms were the first-movers that had achieved this target. Then how did the pattern emerge as executives share authority with subordinate organisational members?

We cannot disclose the sources of Group-B firms in adopting the new social relations totally here. However, associated with our historical retrospect, the diversity among multiple layers and subsystems within national industrial system did work for the emergence of such a change (Lundvall et al, 2002). The personal engineering skills accumulated before the prevalence of TMFT practices, the experience of industrial organising, and especially the memories about *Magnitogorsk Constitution* worked as seeds, waiting for activation by relevant entrepreneurship to catalyse changes. We do not mean that the previous patterns were reproduced by Group-B firms; but the experiences constructed a wider possibility space, associated with the experiences earned from TMFT practices, for the practitioners to develop their own patterns.

Huawei is a typical case. REN is an enthusiastic Maoist[136], which could be reflected by his strategic thinking about development, such as stressing advantageous force on specific targets.

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[135] It was said by REN on Huawei's award ceremony for the marketing and post-sale service departments, Jan 2009.

[136] REN was exactly a "pacemaker of studying Maoism" in the 1970s when he worked as an engineer in Chinese army.

Most importantly, he offers most Huawei's stock shares to organisational members as rewards and responsibility. As the founder, REN only holds 1.42% while the rest 98.58% are owned by 65% internal employees through two unions, which endows organisational members the sense of participation and the foundation for being mobilised and integrated. During our investigation, some Huawei engineers said, "*our boss has only very small share of this firm – Huawei is not his private property. However, he can work so hard, day and night for the collective. Certainly we shall also do like this !* [137]" Even the non-private ownership, which is broadly accounted as the source of principle-agent problem, also presents interesting linkages to the organisational cohesion. HaFei and Chery share the similarity to be SOEs. Also there is about 40% share held by SOEs in ZTE. In these cases the essence of public property does not impede the in-house technological learning, but rather reduces the identity difference among organisational members. For example, Chery's engineers said, "*Chery is not a private firm of YIN and other top managers. It is ours!*[138]"

Besides, at the inceptive stage of all Group-B firms, the pressures as vital for life or death of their firms, the engineer or scientist culture, and the shared strategic intent and memories about previous patterns formed up the complexity, which might be called as fellowship, to push participants to search for consensus about development. Their disadvantages of resource-based endowments and potentials to access external JV partners induced them to rely on the knowledge creation of in-house engineers as the most valuable and dependable "resource". As implied by Grant (1996, 120), if the primary resource of the firm is knowledge, if knowledge is owned by employees, if most of this knowledge can only be exercised by the individuals who possess it – then the theoretical foundations of the shareholder value approach should be challenged. Such situations increased the possibility for practitioners to select or create patterns by which they shared some authorities within a broader scope of organisation, mainly the central part involved in knowledge creation. Such configurations attracted the rebels against the TMFT framework, which enhanced their inclination again.

8.2.3.2 Bandwagon effects of organisational evolutions

Inspired by Schumpeter (1943), *bandwagon effects* are adopted by scholars to describe the emergence of followers upon particular innovation. For example, Perez (2002) stresses a series of social-economic conditions of *bandwagon effects* for critical technological changes. Under the transitional circumstance as China, the emergence of new developmental patterns can be regarded as significant changes in social technology. Then bandwagon effects refer to the following of other domestic firms with regard to learning patterns of first-movers.

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[137] It is according to the interview with LIU ChunQiang (2003, 2005) and CHE HaiPing (2003).
[138] It is according to the interviews with LU JianHui (2003,2004,2005)

(1) Bandwagon effects of TMFT model and SOE reform

In the early phase of the economic reform, the legalisation of government and the ideology played critical roles in mobilising industrial firms to carry out organisational change. The TMFT policy was a typical case. The earliest official articulate clauses for the TMFT policy were not issued until 1994[139]. However, relevant changes had been achieved since the early 1980s by the informal appeals of policy-makers and industrial leaders, and were propelled by the enthusiasm of industrial practitioners rather than the real governmental commands. From 1983 on, Sino-foreign productive JVs had already been established in a rush. Up to 1995, there had been 15,078 with the annual output at 408.8 billion RMB. For many JVs, they were not directly set up or encouraged by central government, but were by the regional governments or superior industrial groups. Followers took the TMFT framework as an advanced pattern to get rid of their weaknesses in management, to promote capability-building, and to increase the profitability. Many SOEs even l actively looked for foreign partners on their own. For example, the connection between Volkswagen and FAW was set up by themselves.

Even without any governmental interference, many private enterprises also spontaneously followed the trends of SOEs reforms, as they just recognised these advocacies as advanced models in the face of the emerging competitive circumstances. For example, in the late 1990s, when the contract responsibility system became the mainstream, even some family-controlled private enterprises also implemented this system to divide authority and responsibilities of different business units among family cycle members[140]. Similar situations happened during late 1990s - early 2000s. When the MBO (Management Buy Out) was broadly advocated as a new pattern of SOE reform, private firms also took it to direct their structure reform, and offered their managers large amounts of share stocks or options. Not until the spread of MBO of SOEs got stopped by the central government by 2005, did the MBO become popular in the Chinese industrial community.

(2) Bandwagon effects of Group-B firms

Along with the successes of Group-B firms, the diffusion horizon of their patterns gets gradually broadened. Firstly, the development of Group-B firms gradually changes the attitude of the government on them. In the telecom-equipment sector, the overwhelming success of leading Group-B firms against Group-A firms was the primary cause. Moreover, some MNCs did irritate

[139] It can be kept open for the further study. At least, according to all governmental officials and researchers in my fieldworks, none could provide an earlier version of official documents. If there had been an earlier version, it was still interesting that most of the officials and researchers were not aware.

[140] For example, Fotile, namely today one leading OEM contractor of kitchen utensils and appliances in the world. In early years, the founder signed a contract with his WIFE in 1985 to help him supervise the firm since he travelled around frequently for marketing.

the Chinese industrial administration. They ever tried to construct their monopolistic power with first-mover advantage by utilising some exclusive technologies. For example, MNCs stuck to the ISDN-PRI (exclusive) technology instead of the No.7 Signalling System (open) technology in Chinese PDSS network before the early 1990s; and they kept the ABis socket in the mobile network locked by their proprietary technology in the late 1990s. These exclusive technologies brought about problems against the interconnection of Chinese telecom networks, and MNCs exhibited arrogance and reluctance to cooperate with Chinese. Only with the contribution of Group-B firms, Chinese regulator could obtain technical solutions and bargaining powers against MNCs. In the car-making sector, the governmental support gradually grow by seeing the increasing market reputation of Group-B firms, especially after the great policy controversy during 2004-2005.

Then, after Group-B firms had proven their in-house capabilities, several ministries announced some treatments to encourage the development of Group-B firms, including taxation favourable treatment, loan from development banks, assistance to promote social reputation and other aids. In addition to bringing Group-B firms with benefits, these measures change the social recognition, and induce social-economic environments to bring up followers. It is to say, the pathways and the patterns of Group-B firms are taken as exemplary advanced models. Domestic firms followed them because they were enlightened, or because of their own imperfections of knowledge -- again, they acknowledged external good experience only within the subsets they really perceived.

Certainly, the most important impetus for followers is the business success of Group-B firms; otherwise, domestic learners would not pursue losers, even in the name of indigenous technological development. For example, in the 1980s, there had been several domestic firms insisting on indigenous product development, such as Panda and Westlake in the TV set manufacturing industry. They ran technology-oriented strategy and followed the logic of "technological breakthrough →new product→ new business", depended on in-house R&D centres that were far away from the business units as for their central concerns. It was an exact inheritance of the command economy, by which S&T divisions were separated from production divisions. They were praised as exemplarity models of SOE reform by government at that time, but later got failure. No domestic firms imitated them; rather, the mainstream of domestic TV-set sector gave up indigenous product development.

The followers of Group-B firms include new entrants, common SOEs and even Group-A firms. In the telecom-equipment sector, UTStarcom (China)[141] and FiberHome could be regarded as the learner of Huawei, ZTE and DTT. Since Huawei is so well known in China now, even domestic

[141] According to the structure of UTStarcom, it is an U.S. based. However, its major business, particularly in early phase, is located in China to provide the PHS equipment for China Telecom and Unicom.

firms in other sectors also aim to follow its pattern. For example, the BYD in the car-making sector claims to take Huawei as its model, and put the large amount of local engineers and researchers as the centre of its developmental strategy. In the car-making sector, GreatWall, ZhongXing and ZhongTai should be included as followers. HaiMa and JAC are two automobile-makers that have non-equity cooperation with MNCs, they also aim to reproduce Group-B firms' pattern. They recruit Group-B firm' personnel, visit Group-B firms for experience, or even ask for the governmental coordination to urge Group-B firms to open for their learning. In the face of social pressures for indigenous innovation, some Group-A firms also aim to imitate the "learning through external cooperative projects". Guangzhou Auto buys a chassis system from Fiat, and establishes cooperation with several specialised technical firms. DongFeng also tries to launch its own car models by outsourcing technical services. Beijing Auto even tries to buy car platforms from Chery and establish corresponding cooperation. However, we should stress that some activities of imitation may just focus on reproducing the trajectory that Group-B firms ever took, following the written rules summarised by Group-B firms, such as what the above Group-A firms do. It is far away from success in reproduce the organisational foundation of Group-B firms.

Last but not least, the successes of Group-B firms re-construct the national innovation system. The supply chains brought up by them are apparently fortunes to the domestic industries. Moreover, their successes highlight the values of specific resources that were underestimated in the previous era, such as the values of well educated R&D research personnel and local research units. Such a change does help the domestic followers in achieving indigenous technological capability building although it sounds contradictory. It is because even though the values and prices of domestic research resources are increased, the pattern of integrating local resources for developmental targets provides followers a cheaper way to organise product development. It is a fundamental quality change, as before the emergence of Group-B firms, to develop indigenous systemic products was regarded as "extremely expensive" by domestic community for their inability. In fact, because of the market-oriented reform, some public research units had been ignored for long. The emergence of Group-B firms is changing the cognition of domestic industrial community, and then re-constructing the industrial structures. The bandwagon effects induce investments to promote the domestic R&D personnel and research units.

8.3 Theoretical revisit: learning and organisation in DCs

Considering conventional literature, a series of implications have emerged through empirical studies on China's car-marking and telecom-equipment sectors.

8.3.1 Divergence of learning of DC firms

The Chinese domestic firms in the two sectors we study manifested divergence in technological learning. The early rapid expansion of production capacities and later the growth of technological capabilities were led by different groups of domestic firms, although we do not mean to neglect the fast or even faster growth of production capacity of the latter group. This finding is new to the classical literature on technological learning in DCs, such as Lall (1987) and Kim (1997). In the conventional literature, productive firms are taken as the most important vehicles and creators of technological capabilities (Enos and Park, 1987; Katz, 1987; Dahlman, Ross-Lason and Westphal, 1987; Lall, 1987; Enos, 1991) in countries that really achieve rapid industrialising *ex post*. However, which kinds of productive firms within the same national economic system can bring better or significant progress of learning has not been explored deliberatively. In other words, academics have not included the divergence of domestic producing firms into their exploration of technological learning, except for some of them (Hwang, 1998; Figueiredo, 2001). However, as revealed by our study, the difference contains the source of dynamics for the failure or success in technological learning.

Again, this finding denies the definition of "*late development advantage*" in narrow sense (Amsden, 1989) and its localised theory in China (such as Justin Yifu Lin, 2003). Certainly, the large volume of well-educated labour allows China to utilise mature technologies transferred from somewhere else by establishing manufacturing capacities. However, the in-house capability relevant to systemic product and complex technology development has not naturally happened to those firms if they only focus on the "*late development advantage*". The transition task of capability upgrade from manufacturing to strategic technological development is achieved by another group of firms. Their successes do not rely on the "*copying*" of foreign technologies, but rely on purposive learning associated with relevant organisational development and resource allocation.

The discovery of divergence between these two groups of firms in fact support the view of Bell and Pavitt (1993) that the extension of production capacity does not necessarily lead to technological capacity in DCs. Moreover, as implied by the Sussex Manifesto (Singer et al., 1970, item16) earlier, development means more than a quantitative increase in production. Furthermore, as pointing out in our case studies, the "technological capability" side, namely Group-B firms, also has good performance of "production capacity" displays not only the difference of trajectories that domestic firms follow, but also at least two other important implications.

Firstly, it obliges a re-consideration of technological capability ladders in terms of catching-up at firm level. On the one hand, in conventional literature, the capability-building trajectories are usually indicated in the bottom-up model as developing from primary capability base, namely the abilities of assembling or manufacturing, to higher-level capability, namely the technical adjustment or improvement. On the other hand, as for the top-down model indicated by some literature (Q. Lu, 2000), the S&T knowledge accumulation embedded in the previous national innovation system is regarded as the foundation to be utilised in the later phase. However, experience of Group-B firms displays a different trajectory. They start building technological capabilities related to systemic product development from the very beginning, which means their capabilities relevant to product and product technology development are constructed along with production capacity from the inceptive stage. Meanwhile they have piped in existing S&T knowledge accumulated by the previous R&D division of central planning system. However, they did not just rely on the existing expertise system; rather, they built their knowledge core by in-house integration, which as we analysed is an organisational process.

Secondly, the divergence of learning performance draws out the difference in organisational learning system of these firms as a better explanation. The influences from organisational systems on technological learning are more significant than as marginal factors. Take the relation between technological opportunities and latecomers' catching-up as an example. During the past 3 decades, Chinese industrial practitioners have faced a series of technological opportunities by the *ex post* perspective. For example, in the telecom-equipment sector, there were emergences of decentralised models of PDSS, the development of intelligent network, the optical fibre technology, and so on. However, every time, it was the Group-B firms who made fast response and mobilised their organisations in seizing these opportunities, while Group-A firms just showed indifferent or inabilities towards these changes.

Organisational learning systems are the platforms to implement effective learning, but also the constraints against learning that they do not support. In this way, the "organisational learning system" is a quasi governance version of Leonard-Barton's knowledge-based view of firm in explaining the core capability and core rigidity[142] (Leonard-Barton, 1992). Comparatively, the concept of "organisational learning system" stresses more on the resource allocation and application, part of which is deep into the source of values and norms of organisations. Certainly, as implied by such a couple of contrastive concepts, namely capability and rigidity, it also indicates the status of Group-A and Group-B firms could be permeable. We stress not the priority of particular organisational system but the correlation between technological learning and organisational systems. It means for good performance, the organisational learning system should evolve for pursuing their target of learning. Otherwise, rigidity could also destroy the established

[142] The four dimensions of Leonard-Barton's Knowledge-based view of firm includes: (1) employee *knowledge and skills*; the knowledge and skills are embedded in (2) *technical systems*. The processes of knowledge creation and control are guided by (3) *managerial systems*. (4) The *values and norms* associated with the various types of embodied and embedded knowledge and with the processes of knowledge creation and control (Leonard-Barton, 1992, p113).

competitiveness. New targets always approach gradually which would require organisational change. For instance, the requirements for Group-B firms in basic research or workshop management for better product or processing quality might rise in order to sustain effective catching-up. Then the organisational learning systems, including the internal authority distribution, the organisational mobilisation and learning integration and the underlying values and norms, should respond to new requirements with corresponding evolution. As well, the organisation itself would get petrified. By comparison with the trend of professionalization, the organisation also has the trend to be petrified to some extent. For example, leading members who steer the organisational learning systems would have possibility to degenerate with their knowledge or visions, especially for the connections to front-line needs. Therefore, the driver of the organisational evolution might be outdated not only for the requirements new in quality, but also for the requirements new in quantity. Just note that in the 1950s, most Chinese backbone SOEs were also built by a group of innovative and aggressive young engineers, but we have seen most of them became laggard incumbents in the 1990s. Therefore, to keep their values or norms consistent with the learning requirements for new challenges, and to evolve their organisations accordingly are critical.

In theory, Group-A firms could also have opportunities to catch up in technological capability. Especially in the car-making sector, Group-A firms have large production instalment and still have the advantage in reputation, marketing network and manufacturing quality. However, it would require the change of organisational systems, particularly their cognition and relevant authority distribution as primary tasks.

8.3.2 Technological learning and organisation

Learning has little significance in the absence of a theory of organisational knowledge (Konut and Zander, 1992, p386). If we place the organisation at the centre stage of technological learning study, the fundamental organisational problem is achieving purposeful, coordinated action from organisations comprising many individuals (Grant, 1996, p117). To those firms in DCs which aim to catching up with international frontiers, their developmental targets which ask for “new-new” knowledge consistently oblige them to construct a smooth and efficient knowledge-generation flow within their organisations. Therefore, the organisational learning systems at least should fulfil two functions of learning, firstly to mobilise front-line practitioners to search and obtain new and possibly heterogeneous knowledge, and meanwhile to integrate the learning of front-line practitioners for collective purposes.

Readers could think that our stress on organisational learning systems is prejudice, and argue that many Chinese firms did not meet difficulties of this kind as to becoming parts of global production networks. That is true that by comparison with Group-B firms in number, more domestic firms had adopted the Group-A model. However, their processes of adaption were realised also associated with the SOE reform, which meant the reform of organisational learning systems did exist. We do not suggest the adaption of organisational systems for Group-A model was easy, especially if considering Group-A firms' difficult processes to promote the production localisation rate in the 1980sn. However, if readers insisted on this point, it might mean the organisational learning system for production localisation was comparatively less complicated to adopt. The underlying knowledge might be more codified, such as the Taylorism and Fordism, and MNCs were willing to spread the relevant knowledge (certainly not all) to China for its own benefits. It might also be easier for the leaders of Chinese firms to require subordinate organisational members to obey to particular rules, rather than to work out patterns for organisational mobilisation, and to generate substantial changes, particularly when considering the social conflicts within firms in past decades.

Through empirical studies, we find that in early phases, Group-B firms maintain the comparative fusible structural organisations in realising the product and technology development tasks. This finding is dissimilar to common experience of large industrial enterprises in developed countries that underlines knowledge specialisation and organisation specialisation (Chandler, 1962, 1990, 2005; Chandler and Hikino 2001; von Tunzelmann, 1995). By contrast, Group-B firms' experience shows that they aim to expand their knowledge scope efficiently, and have their own organisations mobilised across internal boundaries without sticking to the solidification of specialisation. They take the cross-boundary inter-departmental platforms as the major stage for knowledge creation and management, in addition to the professionalised units. The inter-departmental learning activities are endowed with authorities and resources to realise "the autonomy of learning" under the basic organisational framework. As Nonaka and Konono (1998) emphasize the importance of "*Ba*" in the process of knowledge creation, by highlighting its role in providing physical, virtual or mental shared spaces, the cross-boundary inter-departmental platforms and underlying institutions in Group-B firms exactly provide such shared spaces. With the platforms, engineers carry out tight interactions, share the knowledge they individually obtain not matter domain-specific knowledge or context-specific knowledge (Iansiti, 1998), and implement knowledge search, generation and accumulation from colleagues, cooperative partners and customers.

Chandler (1962, 1977 and 1990) argues, by contrast with enterprises before, that the first movers of multi-units enterprises do not stress the direct control over their subordinate units in functions. They instead control the financial data, such as the return rate of assets, which is regarded as an important transition to realise the economies of speed. If we transplant an analogical comparison into the domain of technological learning, similar conclusion could come out. Group-A firms control the technological learning of front-line practitioners by stressing existing technological exemplars. They constrain the authority, resource, interactive scope and knowledge access channel for the learning of front-line practitioners. By contrast, Group-B firms set free the developmental processes for their subordinate professionalised units and cross-boundary teams by providing support with resources along practical projects. They concentrate on the growth rate and the integration of in-house knowledge accumulation. By this way, the institutions to mobilise the organisation, to integrate relevant learning, and to facilitate the accumulation and diffusion of knowledge within their firms are at the focus of their concerns. If we consider the knowledge accumulation for developing systemic products and complex technologies as uneven processes in essence, we can find that decision-makers of Group-B firms mainly allocate their attentions to balance and integrate in-house learning in different fields rather than to supervise the details in process. By doing so, Group-B firms effectively realise high throughput of knowledge generating.

By contrast with Group-B firms, the organisational systems of Group-A firms are unable to realise the high speed of knowledge creation. For their low efficiencies in knowledge creation both in depth and breadth, the practical pathway of Group-A firms in technological capability building is "*YinJin LuoHou ZaiYinJin ZaiLuoHou* (importing "technologies" → being backward → importing again → being backward again, see Liu, 2008)".

The difference between these two groups of firms could be initially solidified from their early stages. The cornerstones were laid when they established their cognitions about the effective pattern of technological learning, and made the selections of organisational building in considering the long-term strategic aims. So considering the argument of Chandler that "*structure follows strategy and that the most complex type of structure is the result of the concatenation of several basic strategies*" (Chandler, 1962, p14), two points must be distinguished: firstly, the transition of structure, to follow strategy, is not costless. It requires time, human force and other resource, and is related to the social and political context within enterprises. Secondly, the decision-makers of transitional firms have to know what the appropriate structure is. The "structure" may not be presented as simply as the implication of "organisational layout" generated by this term. The patterns of in-house administration, coordination and cooperation, and underlying institutions, which buttress the exhibiting structure to be effective, may be more complex, ambiguous, and subtle, and may be partially non-codified regarding its underlying knowledge components. If firms does not have developed clear cognition about the appropriate structure, and could not pay off the cost of transition, structure would not automatically follow strategy effectively. For example, Group-A firms have to get to know the importance of organisational mobilisation and learning integration for effective capability-building first, and then develop their own knowledge and schemes about building their learning systems. Only after that, Group-A firms could have possibility to translate their strategy into appropriate structure.

The difference in cognition influences the strategy making. Take the trade-off about technological integration or outsourcing as an example. In the face of pressures for indigenous product development from the public opinion after 2005, Group-A car-makers began to outsource technological services, or existing technical products in the name of developing in-house product platforms. They claimed that purchasing the well-packaged car model or chassis systems from foreign providers was a better strategy to start from a higher level platform, and to avoid the investment in building lower level capability as what Group-B firms did in their early stages. However, similar to the classical comments on RBV (Dierickx and Cool, 1989), the capability of integration cannot be purchased in any market. Otherwise, Group-A firms should have been advanced in capability-building for years as they had imported advanced car models under the TMFT framework for long. And the Brilliant Auto should be successful in in-house capability building too before 2004.

Furthermore, different cognitions and organisational learning systems also influence the perception about resource pricing. For example, in spite of the sustainable growth of Group-B firms, Group-A firms regard carrying out in-house systemic product development based on the capability of current domestic industry as an extremely expensive strategy. They declare that large production capacities, advanced-equipped laboratories and relevant instruments, large development teams and large financial investments are needed. By contrast, they think the way of importing product models from foreign partners by paying a lot of money as convenient and economical. In comparison to the practice of Group-B firms, different cognitions about technological learning leads to different perceptions about the potential costs in realising the same targets; or we should say potential costs are realised into *de facto* costs through practical experience, which is close related to their organisational learning systems.

8.3.3 Historical and social connection to catching-up firms

So how does successful catching-up of firms come about? According to the historical retrospect, the evolution of organisational learning systems cannot be regarded as an automatic output of aspirations of entrepreneurs. It is generated through interaction with social contexts.

Garud and Rappa (1994, p359) argue that the interaction between the individual cognition at micro-level and the institutionalisation at macro-level unfolds technical development. Institutionalisation, namely the commonly accepted evaluation routines, represents a shared reality that strongly shapes the direction of future technological change. A similar interactive nexus between commonly accepted organisational patterns and individual cognition also underlies the evolution of organisational change, or say, the evolution of social technology.

The emergence of Group-A firms presented the resurgence of *Fordism* in Chinese industrial community, which was connected to the previous industrial experience and political preference after 1978. Along the economic reform, upper managers were authorized with more power, which was realised by institutional reform step by step. It was an outcome of policy-makers' search for solutions to realise rapid industrialisation. Especially after ceasing the antagonism against the capitalism camp, policy-makers looked forward to the productivity growth to ensure the cohesion of the whole society. However, the new authority was not positive in mobilising the mass, as the social mainstream regarded the mid- and lower-level organisation as an important source of low efficiency. Besides, for the actual property right reform, the state-owned assets were indeed in an ownerless situation in the early phase of reform. All these reasons had the upper managers of SOEs to the position to lead and organise reform within the enterprises.

As to upper managers, we should not overlook that they were in theory at an opponent position over the corporate control against the mid- and lower-level organisation. As argued by Lu (1999) on Chinese experience, because the internal relationship of SOEs are highly political-based and the SOEs were obliged to provide a series of welfare in spite of working performance, there was not effective managerial control within Chinese SOEs and the authority inside was in fact decentralised. Granick (1960) also shares this point with the Soviet experience. Therefore, after being legalised with more and more authority, it was not reasonable for upper managers to give away some authority that they just won back against the mid- and lower-organisation. The expansion of upper managers' authority did not originate in the successful technological learning or interaction with the mid- and lower-level organisations, but instead sprang from the top-down institutional reformation. For example, the TMFT framework was a distinct package provided by the government with supporting policies to construct favourable environments for reformed SOEs. Thus in achieving developmental targets, executors of SOEs did not tend to mobilise actively general organisational members, particularly considering the tension brought about by the distribution reform. Rather, they tended to respect resources-based factors and external forces.

The sequence of SOE reform also strengthened the power of upper managers. Even for every step of reform policy-makers called on re-consideration of shortcomings in previous steps. But the reform sequence, namely from the command economic system, to the factory director responsibility system, to the enterprise contract management responsibility system, to the share-holding modernised corporate governance system, and even to the MBO in recent years, in fact continuously enhanced the authority of upper managers in depth. For example, the nominal "*single head system*" was removed after 1992, however the subsequent shareholding-oriented reform legalised the control of upper managers by property-right change. It in fact formed up the path dependence of reforms, by which the mid- and lower-level organisation got really attached to the managers rather than the organisation. Thus, the organisation-oriented system (Dore, 1987; Chan, 1995) is hardly to form up.

As for the emergence of Group-B firms, it is one generic among indigenous attempts to build technological capabilities when the whole industrial system was gradually placed under reform. This was one of organisational innovations carried out in a bottom-up manner by firms rather than central planners at that time. The memories about the previous patterns, and the skills accumulated previously, which are embedded in the domestic industrial community, associated with the uneven economic reform, worked as catalyst for potential heterogeneous changes.

Bottom-up spontaneous organisational innovations happened by all kinds of means. For example, as mentioned, several TV set producers tried to rely on their in-house R&D centres during in the late 1980s; the Wuhan Diesel-Engine Factory adopted the German management system by hire Germany managers; the establishment of GDT was also one attempt to establish a better learning system by incorporating S&T institute and product innovation. However, as we demonstrated, in both sectors we study, there were hundreds of failed cases for such attempts.

Therefore, the emergence of Group-B firms, including their cognition, their selection of learning pattern and their building of organisational systems, as one generic of above attempts, should not be viewed as the simple implementation of particular strategies or learning pathways in general. Latecomer firms are living amidst the marsh other than in the meadow if we discuss the knowledge about practical patterns for upward development, without mentioning their collision with the evolution of mainstream social cognition. So empirically speaking, the establishment of organisational learning patterns of Group-B firms is something innovative under great uncertainty. Meanwhile, their emergence also pushed the social change.

8.3.4 First movers of indigenous capability transition

(1) Drives of change in domestic industrial systems

Our finding about the divergence of indigenous firms in technological learning generates a challenge to the perspective of global production network or global value chain (Kishimoto, 2004; Schmitz, 2007; Altenburg and Schmitz, 2008; Ernst and Kim, 2002; Ernst, 2005, 2007). The local leading firms in terms of technological capability building are not those firms engaged in or previously engaged as dependent in global production networks or global value chains. In fact, Ernst and Naughton (2007) have noticed the different behaviours of Chinese domestic firms and developed a three-tier analytical framework. However, they have not continued exploring the sources of divergence and the further impacts upon technological learning and industrial development. Certainly, these explanations could contingently work since it is possible in theory that flagship or other core firms would continuously transfer modular production tasks to manufacturing firms that reside in DCs (maybe not the same country) for sustainable cost advantage. However, the perspective of global production networks or the global value chains could only interpret some phenomena of the dynamics of China's growth, but NOT the main-track in terms of quality change. Regarding the indigenous breakthrough in systemic products, complex technologies and relevant domestic supporting systems, the first significant moves that elevate the domestic capability from the capability category of the production segment to the product innovation segment are led and achieved by new indigenous firms. Group-B firms also actively employ international resources, but they implement new patterns by contrast with other domestic counterparts do, and take the leading position in the international value networks organised by them -- they are growing from inexperienced integrators to mature ones.

More scholars even have not identified the divergence of Chinese industrial development, such as Nolan (2001), and many Chinese local researchers (such as Lin, 2002). Nolan stresses much the difficulties or even demises of Chinese industrial firms would meet when the China get into the tough global competition (such as join the WTO in 2001), which is right especially for SOEs (Nolan's major objects of observation) during late 1990s - early 2000s. However, he is absolutely wrong about the dynamics of Chinese industrial development with his pessimistic prediction. The limitation of these scholars' insights resides in the neglect of the emerging economic actors in breadth, and the organisational and institutional change in depth. Let us consider the industrialisation in the 1950s, the oscillation of social relation within enterprises during the late 1950s to late 1970s, the SOE reform from 1978, and the emergence of Group-B firms. For every round of changes, there emerged different major forces (i.e. the aids of USSR, the bottom-up efforts of SOEs, the top-down governmental encouragement and the newborn indigenous firms respectively). For every round, the change of organisation and underlying institutions primarily remodelled the cognition, selection and construction of technological learning patterns, say, the organisational and relevant institutional change provided the vehicle for the progress of physical technologies, and formed up the distinguished organisational "revolutions". In this way, disregarding the emerging new forces and disregarding the underlying organisational and institutional changes has these scholars miss a fundamental main-track for understanding the dynamics of Chinese industries.

(2) Role of Government and domestic S&T force

The government's role is also controversial according to the case study presented in this thesis. In the conventional literature, it is broadly accepted that environmental factors and/or governmental intervention influences purposeful efforts of technological learning in industrial firms (such as Dahlman, Ross-Lason and Westphal, 1987). Kim (1997) gives a complex and multifaceted picture of the developmental government in supporting indigenous industries. In his works published in

2000 (Kim, 2000), he generates a more moderate view, as both positive and negative effects are included in his evaluation of the Korean government in promoting indigenous capability building. S.R. Kim and von Tunzelmann (1998) advocate the role of government in bridging internal networks and external networks of Taiwan's IT industries. Amsden and Chu (2003) consider Taiwan's government as the pump that pipes new technologies to indigenous firms so that the government helps firms to overcome the limitations of local networks. In other words, the government leads the transition of capability-building. Mathews (2007) also advocates the role of public "technology leverage institutions" in identifying technologies and designing strategies for developing them locally.

The role of the government displays a multifaceted picture in our empirical study of China. Chinese government plays an aggressive supportive role during in domestic industrial development, as distinctly demonstrated by its manipulation in providing the TMFT framework and pushing the reformation of SOEs. After perceiving the potentials of Group-B firms, the government also gives some aids; and emphasizing on indigenous innovations formally has become the new national strategy after 2005. However, we should not neglect that before that, Chinese government also did negatively on the growth of newborn indigenous firms, intentionally or unintentionally. The legacy of the branch-based industrial administration system and relevant regulations in the name for better economic performance impeded the take-off of Group-B firms again and again in different industries. Therefore, we should recognise that the role of government during the catching-up of DCs is as well a question of its cognition and capability, in addition to the question of aspiration and tactics.

But here, it is clear that during the emergence of Group-B firms, the government was NOT the guide to their new pattern. The government did not know the proper pattern for rapid capability growth in advance, even though it tried all the time and even though it very possibly do not know clear today. In other words, the government is not the first mover to prompt the practical transition from production capacity to technological capability of indigenous firms.

From another perspective, we should say in DCs, the governments are short of knowledge about appropriated patterns of technological learning. According to Chinese case, it manifests clear proves that the government also learned from the growth of Group-B firms. As we said, in the telecom-equipment sector, Chinese government came to realise the force of indigenous firms from the conflicts between Chinese regulator and MNC equipment providers on a series of interconnection problems. Besides, it is also possibly right that the reason for DTT to be transformed into competitive firm much earlier than many governmental industrial research institutes in other industries resides in the fact that the government had witnessed the emergence of *HJD-04*. In the car-making sector, the government began to combine its basic research consignments with the practical product and technology development projects of firms.

Similar discussion can be implemented regarding the role of domestic R&D forces. Before the emergence of Group-B firms, Chinese public institutes and universities had existed for decades. The reform after 1978 led by government had them gradually rely heavily on market transactions. Without any synergy, public research institutes and universities were not welcomed in the economy orientating the production capacity only. The intellectual forces of public institutes kept shrinking, since they were marginalised by the new economic system. They were the Group-B firms who played the roles as integrators of domestic R&D resources and promoted the corresponding values.

Who are the first-movers of important transitions as for the indigenous capability building and for levering the corresponding national innovation system? It may not correct to draw conclusions from empirical study of just two sectors, as what we see might be contingencies only. However, it is apparently that the answer connects to the cognition of learning patterns held by actors and their real practices, not only resides in the quantity of resources that particular actors held and invested. Government, research institutes, universities, incumbent enterprises and even the flagships of global production networks do not have the inborn power to engender effective guidance for the domestic industrial community in realising catching-up. Our study on the success and influence of Group-B firms, namely the first-movers in the two Chinese sectors we study, directs us to stress on the organisational and relevant institutional development.

8.4 Summary

The backwardness of DCs lies not only in their physical technologies, but also in their social cognitions about learning and relevant translations of cognitions into organisations. Through the historical retrospect, we connect the social relations within enterprises to the cognitions and selections of Chinese firms about organisational systems. The counter-opinion to the movement of organisational change that raised by bottom-up forces during the late 1950s to the early 1960s bred the SOE reform starting from 1978, which was also underpinned by a significant political change. The sequence of reform, the inducements provided by government, the financial constraints and the negative attitudes of foreign collaborators on the building of Chinese indigenous technological capability jointly incentivized and framed many domestic firms to adopt the Group-A model. The substantial source of the failure of Group-A firms to achieve in-house capability building rested on the fact that their internal social relations, enhanced by relevant organisational systems and institutions, were incompatible with the rapid and large throughput of knowledge creation that was critical for developing systemic products and complex technologies.

Group-B firms belonged to various spontaneous organisational innovations in the domestic industrial community since the 1980s that aimed at technological catching-up. The previous learning patterns and skills embedded in Chinese society, the particular organisational cultures carried out by their core members, and the resource- and policy-related inducements along the uneven reform process cultivated their organisational development. In order to achieve high throughput of knowledge creation, they adopted new internal social relations, based on which organisations authorised front-line engineers the autonomy of learning with resource support. Acting as the major part of dynamics regarding technological capability building in China, Group-B firms were gradually perceived with their business successes by other domestic firms, and inspired a new round of organisational revolution.

By this way, we see that the influence of organisational systems and underlying institutions upon technological learning is far beyond the general description as simply the organisational structure, the resource investor, the vehicle of human force, or the executor of strategy or tactics. For better understanding about the technological capability building process in DCs, there are still a long set of logics for us to explore, including the historical and social contexts, the cognitive development of domestic practitioners, the relevant social relations within enterprises, the selections and constructions of organisations, the resource allocation and application of firms, the implementation of learning strategies, etc. What we have shed light on in this thesis are only parts of these logics.

Anyway, consider the organisational and institutional connections to technological learning and industrial development in DCs, as Schumpeter (1943, p84) points out, "*the problem that is usually being visualized is how capitalism administers existing structures, whereas the relevant problem is how it creates and destroys them*". How the cognitions and organisational systems are generally changed should be taken as a key question of development study. Abramovitz (1989, p222), from another perspective, throws light on, "*a country's potential for rapid growth is strong not when it is backward without qualification, but rather when it is technologically backward but socially advanced*". Social technologies should be promoted alongside physical technologies (Nelson, 2008). To industrial practitioners, researchers and policy-makers, the dynamic interaction between organisational systems and learning strategy should be placed in one part of centre-stage of their consideration. The relationship between the social relations within enterprises and the organisational learning systems, and their roots in society, also demand studies from policy-makers. Chinese should really do this if their want to develop their country beyond the "world's factory".

Chapter 9. Conclusions

9.1 Introduction

Regarding the technological learning of firms, relevant organisations do matter, which has been broadly recognised since organisations act as vehicles for learning. Nevertheless, how the organisations work during the process of learning, and how significantly the organisations act in the way suggested, remain questionable.

Particularly when considering the backwardness of DC firms in terms of lacking experience about appropriate learning patterns, and considering the requirements of effective catching-up for the continual acquisition of new knowledge, the organisational configuration of learners emerges as a necessary question to explore.

Through the empirical study of Chinese car-making and telecom-equipment sectors, we open up the process of knowledge search, generation and accumulation of the studied firms, and assess the role of the organisational learning system therein. We confirm that the organisational learning system plays several important roles in the processes of knowledge creation of firms. The differences in terms of organisational learning systems among indigenous firms bring to light the differentiated performances of technological learning.

9.2 Reviewing the research question

The primary research question of this thesis is “How can local firms in DCs like China develop their organisations to attain product technologies?” In terms of developing product technologies, we refer to the capabilities of generating and managing technological change related to systemic products and relevant complex technologies with strategic significance. Behind the central research question, we have a key argument that the organisational systems of industrial firms in DCs play fundamental roles for their technological learning. The empirical comparisons between the two groups of firms provide us the foundation for theoretical exploration, and we have set up two hypotheses to examine.

Firstly, we suppose there are significant differences in organisations between the Group-A firms and the Group-B firms, namely two groups exhibiting dissimilar performances in building their technological capabilities. We confirm this hypothesis by studying four major components of their organisational learning systems, namely the strategic intent, the authority over resource allocation, the patterns of organisational mobilisation and learning integration, and the facilities and institutions for knowledge accumulation. Regarding the strategic intent, we cannot develop an effective quantitative instrument, particularly when considering that the two groups of firms both always shared similar starting configurations of intent to develop indigenous technological capabilities. However, based on observation of their long-term activities, we can differentiate the evolution of their strategic intent by qualitative analysis. As for the other three components of organisational learning systems, we get striking contrasts between these two groups of firms.

The second hypothesis is that the organisational differences observed are deeply involved in the processes of knowledge creation of firms. We confirm this hypothesis through a detailed study of Group-B firms' mechanisms of knowledge search, generation and accumulation in their early stages. Certainly, we cannot cover all aspects of the knowledge creation processes, but we choose to highlight three mechanisms that were essential (according to our investigation) to Group-B firms, namely learning through recruitment, learning through external cooperative projects and learning through interactions with customers. Our study reveals that in Group-B firms the organisational arrangements actually provided practitioners with autonomy of learning, and provided relevant platforms to facilitate or filter their learning activities.

In the following subsections, brief summaries of analyses about the components of an organisational learning system are presented.

9.2.1 Differences in organisational learning systems

(1) Strategic intent

Regarding the strategic intent to build up technological capability, all of the indigenous firms we study always had such intent. The TMFT framework that in fact brought on the Group-A firms had an articulated target to promote indigenous technological capabilities through close learning from foreign collaborators. Nevertheless, because of the governmental inducements, the foreign partner attitudes and the financial concerns, Group-A firms had not placed the in-house technological learning for systemic product and complex technology development at the centre of collective learning along with the production localisation. In addition, their organisational systems proved to be inconvenient for rapid and large throughput knowledge creation. Thereby, they had not actualised this original intent into organisational practices, and were gradually captured by the benefits from being manufacturing bases of global production networks.

By contrast, Group-B firms insisted on their intent to build up in-house technological capability. They consistently invested in projects related to the development of systemic products and complex product technologies, despite the difficulties associated with tight resources in their early phases. In their early stages, Group-B firms took these projects as centres for organising their relevant investments and learning activities.

(2) Authority over resource allocation

Group-A firms were dominated by managers and engineers who grew up from manufacturing, marketing, financial, or even political work divisions. Even though some Group-A firms had experience related to systemic product development before they adapted themselves to the TMFT framework, relevant product development engineers had little voice on top committees. Such a situation could be attributed to the stresses on production localisation, the historical legacies as ever influenced by the USSR factory model and the comparative disadvantage of in-house development engineers by comparing their foreign experts, and so on.

Top management committees of Group-B firms were dominated by people with backgrounds in developmental activities, especially the activities of product or product technology development. Such a tradition originated from the product-oriented competitive strategy held by Group-B firms, and was influenced by the legacies of their founding teams.

With regard to the distinctive differences on top committees of these two Groups, we can see that their strategic resources were allocated in dissimilar ways. In Group-A firms, without effective mechanisms to communicate with developmental engineers, it was difficult for top committees to understand the requirements related to development of systemic products and complex product technologies. However given the growth of production capacity and the cooperation with giant MNCs, the committees did think they knew very well about how to develop in-house technological capabilities. Consequently, what we can see was not that Group-A firms had never invested in R&D. Rather, Group-A firms always invested R&D funds in the places that they thought to be right. In Group-B firms, along with the leading role of developmental engineers in the authority structure, there were in-depth interactions between top managers and practical developers to facilitate the decision-making. The force of developmental engineers led the allocation of strategic resources and the scheduling of relevant projects. In fact, supported by the patterns of organisational mobilisation and learning integration, some resources for developmental projects were entrusted to front-line participant units, by which practitioners could respond to the requirements emerging from developmental processes in real time.

(3) Patterns of organisational mobilisation and learning integration

Since the prior target of Group-A firms was to imitate the existing imported technological blueprints and relevant methods of implementation, they established highly professional but rigid organisational systems. The tasks of production localisation were divided into specialised pieces, taken on by different units at different levels. Within such a system, front-line practitioners were discouraged to be mobilised or to generate heterodox thinking. Rather, chiefs of units worked as gatekeepers of knowledge conversion to regulate the target and ensure efficiency. Except for irregular projects, the communication scopes of common engineers were restricted within their units, which were applicable to both the production-relevant units and R&D-relevant units.

Group-B firms had been carrying out complete sets of developmental activities in-house, and had placed the development of systemic products and relevant technologies at the centre of resource mobilisation and task scheduling. Significant shares of the learning activities were carried out on cross-boundary inter-departmental platforms. The communication scopes of front-line engineers were broadened to include general relevant units; the levels of communication had also been deepened by which relevant co-operators could interact on in-progress developmental activities on each side. With supportive resources, front-line practitioners were encouraged to mobilise relevant units and co-operators according to the needs emerging from knowledge creation in real time. The processes of knowledge search, generation and accumulation were supervised by a series of basic institutional frameworks only, e.g. the scheduling, the intensive interactions, the on-site discussion, and the regulation for knowledge submission, etc., which were essentially aiming at supervising the speed and the integration of knowledge creation, rather than supervising the detailed contents of learning.

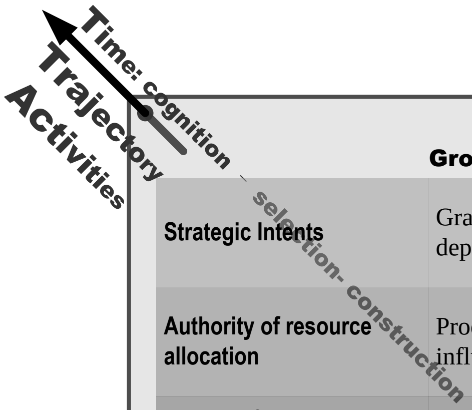
(4) Facilities and underlying institutions for knowledge accumulation

There was no comprehensive knowledge database in Group-A firms. Group-A firms did not even have complete sets of blueprints of imported product models. Knowledge accumulation was dominated by chiefs at different levels. The chiefs and professional assistant members worked as producers and key-keepers of knowledge databases. The knowledge accumulated was delivered to common members in forms such as manuals or regulations for production or development operations; these outcomes (i.e. the manuals or regulations) being updated only after periods of years. For some cases, the manuals were no more than translated versions of original foreign manuals. The lack of active comprehensive knowledge databases restrained the processes of knowledge conversion within Group-A firms.

Group-B firms had established comprehensive knowledge databases in addition to departmental databases. Associated with developmental projects, organisational members were regulated and encouraged to contribute their learning outcomes to collective databases; Group-B firms also raised a series of specific programmes to enhance the speed, the quantity and the quality of knowledge accumulation. As for application of the databases, under some basic regulations, members in general could access the knowledge databases to consult, revise, upgrade, and apply the knowledge accumulated. In fact, as the knowledge databases of Group-B firms were built in a highly interactive and active manner of front-line learners, the databases actually acted as important physical platforms for developers to carry out projects and technological learning.

We list the comparisons of organisational learning systems between these two groups of firms in Figure 9.1.

Figure 9.1: Differences of organisational learning systems



	Group-A firms	Group-B firms
Strategic Intents	Gradually captured by benefits from dependency	Insist on capability-building
Authority of resource allocation	Product developing force has little influence	Dominated by product developing engineers
Pattern of organisational mobilisation & learning integration	Professional, specialised but rigid; knowledge gatekeeper for every unit	Specialised units; platforms across-departments; regulations only for ensuring the framework
Knowledge accumulation	No comprehensive database; collected & kept by gatekeepers; updated only phase by phase	Comprehensive database; generally open to members; updated JIT; as the platform of technological learning

9.2.2 Organisational learning systems and knowledge accumulation

The relations between the organisational learning system and the processes of DC firms in carrying out knowledge search, generation, and accumulation have also been examined. The hypothesis is confirmed that the knowledge creation processes in Group-B firms were closely related to the differences of their organisational learning systems by contrast with those of Group-A firms.

(1) Learning through recruitment

From existing knowledge carried by individuals, the organisational learning systems of Group-B firms provided platforms for individuals to generate mutual understanding of one another along with developmental practices. Such processes brought about combinative understandings that were new to their firms or even to the domestic industry community. The above platforms, based on the intensive interactions of their members, were also important to bring on junior engineers who were large in number, and were important for realising the learning strategies of Group-B firms. During the learning through recruitment process, the authority over resource allocation assured the funding for practical projects which acted as practical vehicles for interactive activities; the organisational mobilisation and learning integration provided institutional ties for bringing about mutual understanding and further knowledge based on collective efforts; the knowledge databases worked as facilities to propel knowledge diffusion which also enhanced interactions.

Meanwhile, the organisational learning system also worked as the filter to direct collective learning. If the contents or mechanisms of knowledgeable advocacies were incompatible to the absorptive capacities or the underlying platforms of firms, such advocacies would be excluded by the organisational learning system. The failure of “returnee stars” exactly exhibited this point.

(2) Learning through external cooperative projects

To transfer knowledge from external knowledge highland inward and to create new knowledge through external cooperation purposefully were important for building capabilities in Group-B firms. The organisational learning system worked as both propellers and filters during these processes. Firstly, the strategic intent and authority armed the involved teams with resource and authority support to learn from external co-operators. The organisational system provided support as fast responses with multiple technological competences for delegate teams to search and develop knowledge on-site. With efficient and in-depth communication, the home base could also relay the knowledge search by catching the contingent contexts of knowledgeable threads over distance. Knowledge databases were necessary for such a mood of communication and collective learning that involved multiple departments and teams. Besides, fast responses and effective interactions among participants units were also critical for avoiding the learning activities from being directed towards attempts much beyond the in-house absorptive capacities.

(3) Learning through interactions with customers

Learning through interactions with customers needed to be accomplished by the integrations of three organisational parts: forward customer service teams, home-base product development teams and specialised R&D departments. The strategic intent and authority over resource allocation of Group-B firms ensured that not only the processing technology development but also the product technology development were put into the foreground for serving customers. The patterns of organisational mobilisation and learning integration generated fast responses and support, which were provided with multiple technological competences by home-based teams and departments, for the forward teams to realise problem solving and knowledge creation through their interactions with customers on-site. Knowledge databases were obviously important for keeping communication and preserving knowledge linkages among different parts of the organisation during such processes.

For all three mechanisms, the social relations within their organisations prompt decision-makers to rely on front-line practitioners in the search, generation and accumulation of knowledge, for which resources were partly entrusted to the front-line. Therefore, engineers had comparative autonomy to cope with the complexities emerging in real time, which might be located in interaction with colleagues, in working with external co-operators, or in on-site customer service.

9.3 Original contribution of this research

As mentioned previously, our research is constructed from a critical inheritance of "assimilation theories". The contribution of this research then primarily resides in the criticisms and further development we have made in this thesis, by comparison with those theories.

Compared with orthodox assimilation theories, a primary contribution of this research lies in its *advocacy* of emphasizing that organisational change ought to be at the heart of research ino technological learning in China. First of all, through the empirical studies of two Chinese sectors, we present some new findings. By contrast with the conventional 'ladders' in the literature depicting the processes of capability building of DC firms, we emphasize continual progress of capability building based on particular organisational systems, as described in Figure 7.3. There are differences between firms in terms of capability building, by which different groups of Chinese firms can be mapped into different steps of the 'ladder' of the conventional literature. However, our study reveals that it is differences of organisational construction other than other time-dimension ladders that lead to the notable distinction of capability building. That is to say, emergence of in-house technological capability is not certainly the next step of development of the Group-A firms, as the Group-B firms had not been obsessed by what the Group-A firms kept doing in the past three decades. Furthermore, considering the significance of the organisational differences among firms and also how such changes go along with China's development over a longer span of time, our research implies that, even under a particular techno-social paradigm, the process of technological catching-up in DCs can possibly be driven by organisational changes in a discontinuous manner. The essential distinctions of technological learning between generations of firms are mainly framed by their organisations.

Therefore, as regards the research community concerning technological learning in DCs, a primary contribution of this research is to locate the organisational changes at the centre of research. We present an analytical framework of the *organisational learning system*, examine it by a comparative study between the two groups of firms, and attest to its robustness by studying the detailed learning processes of Group-B firms. The framework is not the first to explore the organisational elements on the topic of competitiveness at firm level, when referring to the works of some forerunners (e.g. Hannan and Freeman, 1984; Tushman and Romanelli, 1985; Leonard-Barton, 1992). Ours also has not covered every aspect of organisation. However, it is a new set for studying organisations in the circumstance of DCs with a purposeful target of technological catching-up; particularly it focuses on the continual needs of DC firms to obtain new knowledge for realising sustainable capability building.

Our emphasis on organisational systems of learners challenges the traditional views that mainly stress the implementations of learning, resource-centred investments and strategy-making in choosing directions or trajectories, in studying capability building by DC firms. Our discoveries also challenge the popular application of "absorptive capacity" based on in-house R&D and generic investments. Instead it indicates that, even with intensive governmental support, comparatively large resources, and comparatively high absolute amounts of R&D investment, Chinese Group-A firms still fail to achieve their original intent to build technological capabilities. That is to say, even with purposeful learning plans and strategies, some advantage of resources would not definitely bring about efficiency of learning.

In emphasizing the organisational learning system, we do not mean to demote the significance of resources, strategy, learning implementation and global connections of DC firms during their catching-up. We also do not deny some firms that have been studied by scholars with conventional assimilation theories did succeed through the trajectories described by those scholars, e.g. the Korean firms in Kim (1997). Rather, we are questioning the logical robustness between the measures developed and the phenomena explained. We severely lack substantial evidence that only the quantitative advance of technological expertise could bring about step-phase transitions of capability building. Our doubt is strengthened by considering the extent of divergence among DC firms. Large numbers of DC firms deviate from sustainable capability growth or fail outright, but resource-centred projects for learning are/were popularly implemented by them all along, which have/had not secured their learning performances universally. Therefore, we should be seriously cautious about the explanation we adopt and the phenomena we interpret, especially if we aim to generate beyond contingent or *ex post* explanations of the phenomena observed. Even for interpreting successful cases, being short of insights about qualitative changes, researchers usually have to take the discontinuity of product to manifest the discontinuity of technological capability (Pavitt, 1998), or equate the discontinuity of equipment implementation or cooperation with foreign partners to the upgrading of capability. It is a fundamental limitation of the RBV approach that relevant explanations are obsessed by resource-consuming processes, which generate the *services* directly and contribute to their contingent essence of interpretative power.

But here we do not suggest the priority of particular organisational structures. Rather, industrial firms should adjust their organisational systems dynamically according to evolution of learning targets and external circumstances. Considering the practical inertia and rigidities of organisations, a deduction can be drawn that the processes of technological catching-up by DCs are not likely to be achieved continuously by some fixed industrial firms unless the firms are too big to fail, or the firms are robust enough in financial capability or market power to survive internal organisational transitions, such as the *Chaebols* in Korea and the *Zaibatsus* in Japan, possibly.

The source of potential discontinuities of catching-up processes, whether in terms of the change of organisational systems or the change of organisational bodies, originates from the tensions between the complexity involved in capability building and the limited knowledge of DC practitioners; besides, organisations of firms have roots in social cognition, which contribute to their rigidity in addition to their essential inertia. Therefore, as latecomers, DC firms are not just 20 metres behind the starting line of counterparts in developed countries, if we compare the situation to a running competition; they are standing in a totally different lane. Just quantitative change is then insufficient to realise substantial catching-up. Many popular explanations about how DC firms acquire specific knowledge from the technological highlands, or how DC firms have their employees trained by foreign experts, or how much such firms invest in specific technical domains, etc., help with understanding quantitative change of DC firms in their existing frameworks of knowledge creation. To study the emergence of practices for building capabilities in a new category, qualitative growth, namely the change to learning to organise and of underlying institutional elements, should be located at the centre of the research. Research into quantitative change could be framed and reinforced by such understanding of qualitative changes.

But, again, for DC firms, this 'scarcity' is applicable not only to knowledge about appropriate organisational patterns, but also to that about changes of organisational systems and underlying institutions as processes to realise the appropriate organisational patterns. To explore how they develop the cognition or organisational patterns, we are obliged to investigate the social and institutional changes, and to open a perspective of the *techno-social paradigm*.

Regarding the literature focusing on organisational learning, our empirical study also suggests a concept of "economies of speed in knowledge creation", which at this early stage is still a rudimentary, theoretical attempt. The speed of knowledge creation is important because the contexts relevant to knowledge or threads of knowledge would be comparatively unstable, as they embody loci and relationships of factors and participants. These contexts of knowledge creation may need to be explored promptly; otherwise, some factors, participants and relations would change soon or vanish. Such a feature of technological learning should be highlighted for DC firms since they are generally short of experience related to the generic new knowledge that they are seeking, including systemic knowledge and specialised knowledge. Such a situation increases their difficulties in reproducing the contexts of knowledge creation, and accelerates the vanishing speed of knowledge creation contexts for them. So in many cases, to realise the economies of speed in knowledge creation requires organisational integration of firms that can construct a foundation of multiple disciplinary competences and relevant authority. Moreover, the catching-up tasks of DC firms enhance the requirements for them to speed up knowledge creation: they not only need to acquire and assimilate the knowledge not new to the global community but new to their local contexts in order to close the existing capability gap with the frontiers, but also need to create new knowledge to compete against international rivals, gain sustainability and close the dynamic capability gap.

In response to the speed economies of knowledge creation, we develop a concept of "autonomy of learning" based on the practices of Group-B firms. Front-line units for developmental tasks in Group-B firms are not supervised by higher authorities for their detailed contents of learning, but only for the dimensions of speed, integration, submission, etc. To achieve such autonomy, some requisite resources must be entrusted to front-line units, and the front-line practitioners must be authorised with the rights to mobilise relevant co-operators and knowledge accumulation (databases) according to the challenges emerging from developmental process in real time. Again, these preconditions suggest the importance of organisational learning systems.

As regards the study of sectoral innovation systems, this thesis provides a historical and detailed study of two Chinese industries. We demonstrate the historical and organisational sources of the divergent development of firms, and explain the special developmental pattern of Group-B firms. This enriches the empirical studies of the research community.

9.4 Implication for policy-makers and industrial practitioners

As we implied, the government is also a learner during the catching-up of industries of its country, and Chinese government has not exhibited satisfactory performances by its policy outcomes as Group-A firms had not achieved or even close to the original target of indigenous technological capability growth. In various industries, the growth of Group-B firms that causes disruptive changes of the domestic industrial systems is mostly, if not all, out of the schemes of policy-makers, as policy-makers even tried to hinder Group-B firms when they supported Group-A firms with profitable business models. The contradiction between the outcome and the scheme of policy-makers indicates the underlying limitation of their cognitions and capabilities.

If turning back to the linear model of technological learning ever held by the Chinese government, it can be seen policy-makers did not realise clearly the distinction between production capacity and technological capability for most of time. They thought the indigenous technological capability could grow automatically along with the production localisation of components or products. The neglect of the relation between the organisational systems and the technological learning underlies their linear model, and they took the advocacy of MNCs as advanced models for Chinese firms to follow but with aims to be effective product developers rather than manufacturing plants only. Besides, the government also gave wrong inducement to its backbone SOEs. The business model based on TMFT framework incentivized Group-A firms to stretch their production capacity rather than to risk technological development related to systemic products and complex technologies. When the TMFT business model continuously generated satisfaction for Group-A firms only by the growth of production capacity, Chinese government had not adjusted the policy packages in time. Its inertia and underlying lack of relevant depressed the potentials of industries to carry out any significant changes to realise the original targets.

Therefore, Chinese policy-makers should primarily update their views and knowledge about learning. The advancement of capability-building should not be identified by the products manufactured or by the quantity of R&D investments only, but should be identified by the mainstream organisational activities implemented by domestic firms. Particularly after China claimed the new national strategy favouring the indigenous innovations and the quality of growth in 2005, the concern about effective organisational learning system should be stressed to avoid potential abuses. For example, some domestic firms raised unrealistic targets of technical exploration by investing in marginal projects and hid their reluctance in making quality change. Some MNCs advised to indentify the capability-building by the products related to high-tech activities (such as the debugging for software development). More tricks of this kind did happen after 2005.

The legacy of previous TMFT inducement should be laid off or should be appropriate revised in considering the current production capacities in corresponding industries. Rather, as the progress of capability-building requires the evolution of organisational learning systems, which as simplified, embodies as the intra-organisational linkages of resource allocation, application, and information channels, and so on, relevant successful experiences should be incentivized as exemplar by the government in projects it directly involved. If the government has organised sufficient competences of analysis, policy-makers could even try to codify the experience of exemplary cases. Then the government could enhance its own capabilities to understand of technological learning process, and spread to a broader domestic scope. Besides, as for the basic or long-term research, the government should not provide incentives to firms and stop carrying out nominal “cooperative” projects that indeed heavily reside in participant firms. On the contrary, Chinese government should rebuild its governmental R&D division, which would be specialised in basic and long-term research but follow the new way of administration: the scope of domain involved should mirror the integration of multiple-discipline knowledge as the responding industry does. By doing so, the government can accumulate more relevant knowledge about the industries, cultivate the reserves for top-level human resources, and help the industries to overcome critical technical problems.

However, the cognitive limitation of government and industrial practitioners does not only come from their strategy, but also from the social relation foundation. As pointed out by F. Lu (1999, 2000), the lack of managerial control for the tight political relations among different level of people within Chinese firms under the socialism configuration was the source of low efficiency at that time. However, during the economic reform, the social relationship within enterprises was not deliberately changed to get rid of the weakness as supposing the reformer knew clearly the problem. Rather, the efficiencies, disciplines, subjective initiative and creativities of mid- and lower-level organisation were simply blamed and quenched, and the reform of firms in fact relied mostly on upper managers. The control held by managers was rebuilt by depriving the negotiation power from the mid- and lower-organisation over the skill, production and development processes.

9.5 Further topics to explore

In this thesis, it is stressed that organisational learning patterns work a critical role in the technological learning of catching-up firms. However, as our framework might miss other critical components of organisational learning system, this concept is worth further exploration. Further studies, which are based on empirical research in other industries, in other countries and under other temporal circumstances, are helpful to criticise and complete the framework. More light should be shed on the sources of organisational learning systems of Group-B firms. For example, how did the founding members of Group-B firms develop their cognitions about effective technological learning which were different from the mainstream at that time, and how did they allow the new social relation develop within their organisations?

Other actors involved in the catching-up processes of DC firms should also be studied by analytical frameworks centring their learning mechanisms, such as the government and the governmental research units, as we see they are far away from having perfect knowledge about learning as well. So during the processes of technological catching-up of related industrial firms, how do these actors, such as the central government, obtain information, cause internal cognitive shifts and raise in-house organisational changes to cope with the external challenges?

Certainly, according to our experience, the analytical frameworks for the learning processes of these actors should be placed under historical contexts. To explore the historical and social connections to their cognitive and organisational changes is another big task to do.

Appendix

Appendix-1 The Neglect of in-house Product Development of Group-A Firms

Table A-1.1 The neglect of existing in-house product platform of group-A Firms

Firm (time of 1st JV set-up)	Car model	Note
FAW (1991--)	RedFlag (1958-1994)	RedFlag is regarded as the national car for its significance of social identification. During 1958-1994, there were two generations and 7 models developed for mass production, and more models for experiment and special use. Since 1994, RedFlag was transplanted onto the platform of Audi 100 C3-GP for mass market, and onto the Lincoln-TownCar for high-end market.
DongFeng (1992--)	None	DongFeng was the 2nd largest truck provider before setting up relevant JVs.
SAIC (1985--)	Shanghai (1958-1991)	The production of Shanghai was finally stopped in 1991.
Beijing Auto (1983--)	BJ212 (1964-2001)	BJ212 contributed 90% profits to the Beijing-AMC/Chrysler before the mid 1990s, got an upgrade for the bodywork only in 1993.

Table A-1.2 New systemic products developed by Group-A firms under TMFT policy (-- 2004)

Firm	New Model of Product	Note
FAW	SanKouLe HongTa	SanKouLe was developed by a group of engineers spontaneously without official support of FAW; HongTa was developed by a regional branch focusing on truck division. There was no official connection to the headquarters of the car division of FAW in technology. Neither SanKouLe nor HongTa had been produced by large batches.
DongFeng	XiaoWangZi	This was developed by a service subsidiary of DongFeng Group without any formal connection to the automobile divisions of DongFeng; It had been produced only by small batches.
SAIC	QiLin, Phoenix, KunPeng	All the three were developed by PATAC. They were concept cars only and were not engineering industrialised for the mass production.

Appendix-2 "Indigenous" Product Development Projects Claimed by Group-A firms after 2004

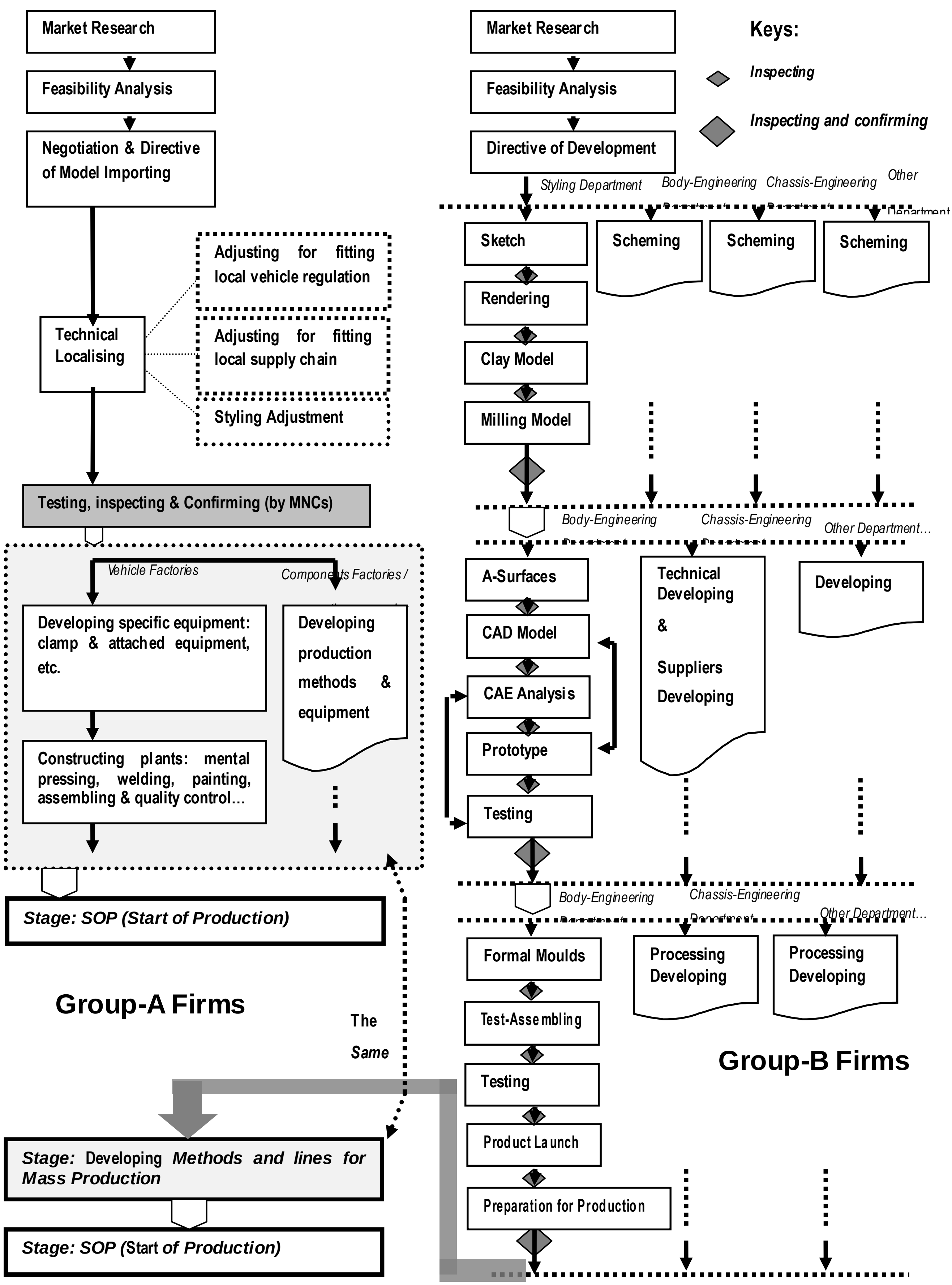
Table A-2.1 New "Indigenous" Products of Group-A firms after 2004

Car model	Contractor & Tech source	Notes
FAW		
C301 (Besturn)	Styling & Bodywork: Italdesign, Italy; Chassis: Mazda *(Mazda-6*, or *Ford CD3*)	Launched in market in 2006
HQ3 (RedFlag)	Platform: Toyota (*Grown-Majesta* 2004 v.)	Launched in market in 2006; based on the *Grown-Majesta* (2004 v.), only a few adjustments of bodywork were made.
HQE (RedFlag)	Whole car development: Toyota	Launched in 2009 for small batch high-end market; the development was led by a Japanese firms in Japan.
SAIC		
SsangYong series SUVs	Whole car: SsangYong, Korea	This series includes the platforms of Rexton II, Kyron, Actyon, Rodius etc.; SAIC acquired 48.9% share of SsangYong in 2004.
Roewe-750 series	Platform: Rover (Rover-75); Adjustment: Ricardo2010*	Only marginal adjustments of styling and bodywork had been made, which were carried out by Ricardo2010. SAIC bought the Rover-75, Rover-25 and all Rover engine blueprints in 2004; in 2007, SAIC acquired Nanjing Auto. Then, it got all rest assets of Rover, including the brand and factories in Longbridge, UK.; Launched in 2007.
Roewe-550	Platform: Ricardo2010, R&D centre of SAIC in Shanghai; Styling and bodywork (partly): Bertone, Italy	The platform was inherited from the Rover-RDX60 project, which was started in 2000 by Rover to provide an upgraded platform to replace Rover-25, Rover-45 and MG series. The project was stopped for bankruptcy of Rover and restarted for the takeover of SAIC. The development tasks were mainly implemented by Ricardo2010; Styling and bodywork designs were outsourced from Bertone. SAIC Shanghai R&D Centre assisted for the Chinese elements in bodywork design. Launch in 2008
MG series (MG-TF, MG7 & MG3SW)	Platform: MG-Rover	The series were produced by Nanjing Auto. Launched in 2007.

*Note: *Ricardo2010 was founded by Ricardo in 2005 at Leamington, UK, with 100% of the fees provided by SAIC, which aims to recruit experienced engineers from Rover and serve the outsourced projects of SAIC only. SAIC set up the SAIC Overseas R&D Centre (Europe) in the same building as Ricardo2010 is in. However, except for the duties of the administration staff, all the development tasks are carried out by Ricardo2010. In 2007, SAIC officials acquired Ricardo2010 and renamed it as the UK Technical Centre Limited, SAIC Motor. There are 200 experienced engineers at this centre. Among the engineers, 150 are non-Chinese, 80% of who were former employees of Rover (data from 2006).*

Appendix-3 Comparison of developmental activities (car-making sector)

Figure A-3.1 Comparison of developmental activities (car-making sector)



Market Research
Feasibility Analysis
Negotiation & Directive of Model Importing
Technical Localising
Adjusting for fitting local vehicle regulation
Adjusting for fitting local supply chain
Styling Adjustment
Testing, inspecting & Confirming (by MNCs)
Vehicle Factories
Components Factories /
Developing specific equipment: clamp & attached equipment, etc.
Developing production methods & equipment
Constructing plants: mental pressing, welding, painting, assembling & quality control...
Stage: SOP (Start of Production)
Group-A Firms
The
Same
Stage: Developing Methods and lines for Mass Production
Stage: SOP (Start of Production)
Market Research
Feasibility Analysis
Directive of Development
Keys:
Inspecting
Inspecting and confirming
Styling Department
Body-Engineering
Chassis-Engineering
Other
Sketch
Scheming
Scheming
Scheming
Rendering
Clay Model
Milling Model
Body-Engineering
Chassis-Engineering
Other Department...
A-Surfaces
Technical Developing
&
Suppliers Developing
Developing
CAD Model
CAE Analysis
Prototype
Testing
Body-Engineering
Chassis-Engineering
Other Department...
Formal Moulds
Processing Developing
Processing Developing
Test-Assembling
Testing
Product Launch
Preparation for Production
Group-B Firms

Appendix-4 Continuously setting up Sino-foreign JVs by Group-A firms

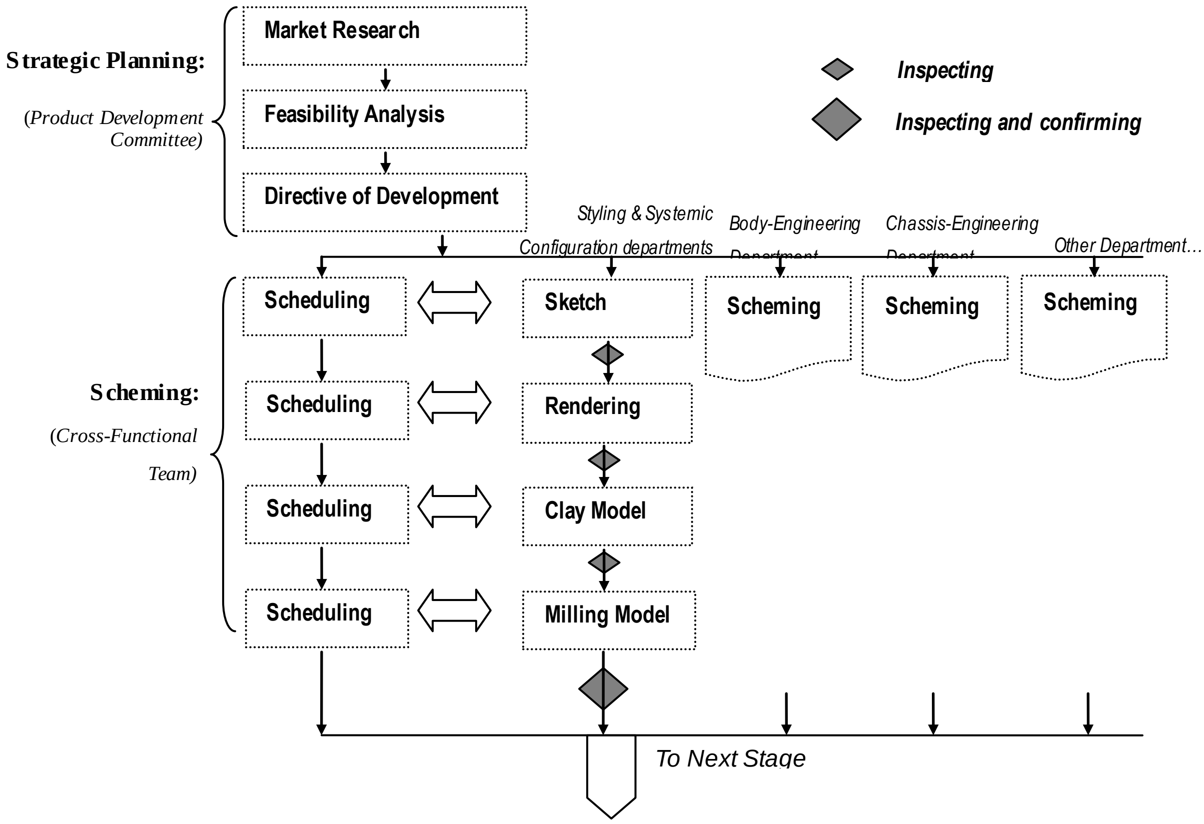
Table A-4.1 Continuously setting up Sino-foreign JVs by Group-A firms

Year 0 engaged by TMFT	Year 0 – Year 5	Year 5 – Year 10	Year 10 – Year 20	Year 20 --
FAW The last date of JVs: 2041				
1988	**1988-1993**	**1993-1998**	**1998-2008**	**2008 --**
1988, importing technologies of Audi-100; (CKD assembly)	1991, Setting up JV with Volkswagen for 25 years	1998, setting up Sichuan-FAW-Toyota for 30 years.	2000, setting up FAW-Toyota for 30 years 2002, extending the JV contract with Volkswagen for another 25 years 2004, setting up productive cooperation with Mazda (FAW-Hainan-Mazda) 2005, setting up another productive cooperation with Mazda (FAW-Mazda)	N/A
SAIC The last date of JVs: 2030				
1983	**1983-1988**	**1988-1993**	**1993-2003**	**2003 --**
1983, Importing technologies of Santana (CKD assembly)	1985, setting up JV with Volkswagen for 25 years		1997, setting up JV with GM for 30 years	2002, extending the JV contract with Volkswagen for another 20 years 2002, setting up another JV with GM (SAIC-GM-WuLing)
DongFeng The last date of JVs: 2053				
1992	**1992-1997**	**1997-2002**	**2002-2012**	**2012 --**
1992, setting up JV with Citroen	1997, Setting up JV with Honda (Guangzhou-DongFeng-Honda)	2001, setting up JV with Kia (DongFeng-YueDa-Kia) for 30	2003, setting up another JV with Honda (DongFeng-Honda);	N/A

		years 2002, upgrading the JV with Citroen to be DongFeng-PSA	2003, setting up JV with Nissan for 50 years	
Beijing Auto The last date of JVs: 2035				
1984	**1984-1989**	**1989-1994**	**1994-2004**	**2004 --**
1984, setting up JV with AMC	1987, upgrading Beijing-AMC to be Beijing-Chrysler (JV)		2002, setting up JV with Hyundai (Beijing-Hyundai) for 30 years	2005, ending the Beijing-Chrysler, setting up a new JV (Beijing-Benz-Chrysler) for 30 years
Guangzhou Auto The last date of JVs: 2034				
1985	**1985-1990**	**1990-1995**	**1995-2005**	**2005 --**
1985, setting up JV with Peugeot			1997, ending Guangzhou-Peugeot; turning into a JV with Honda (Guangzhou-DongFeng-Honda) 1998, setting up another JV with Honda (Guangzhou Honda) for 30 years 2004, setting up JV with Toyota (Guangzhou-Toyota) for 30 years	

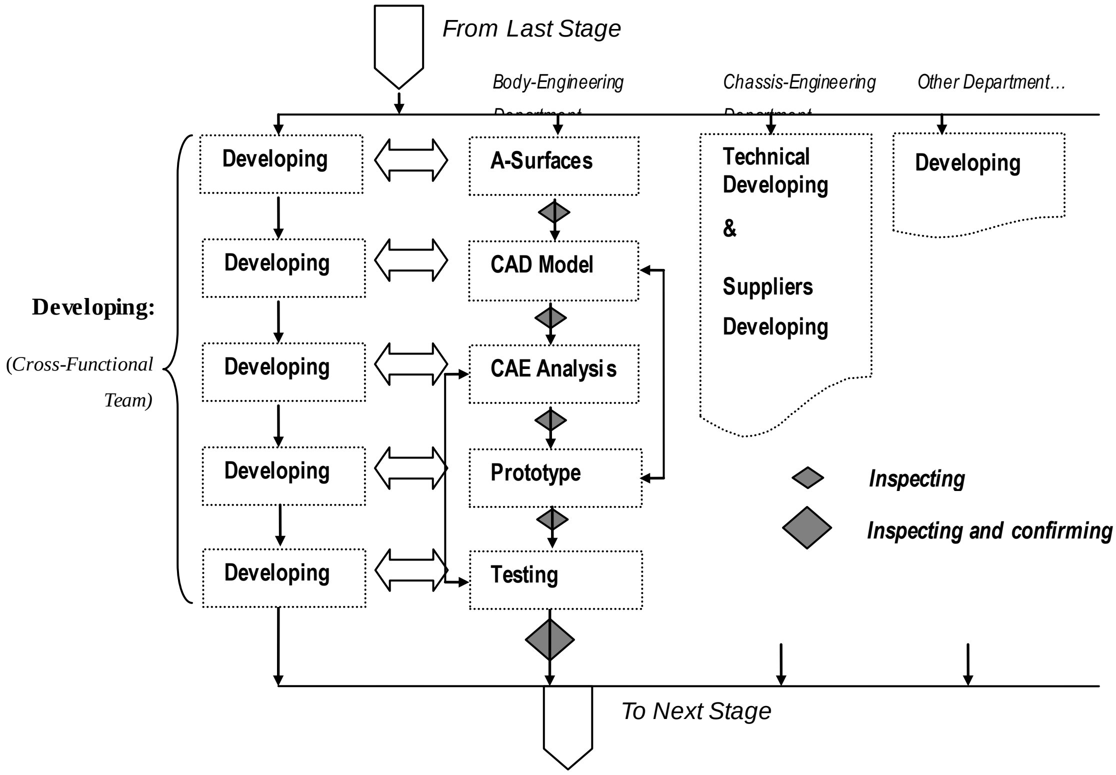
Appendix-5: Different stages of product development in Group-B firms

Figure A-5.1 Planning Stage of product development in Group-B firms



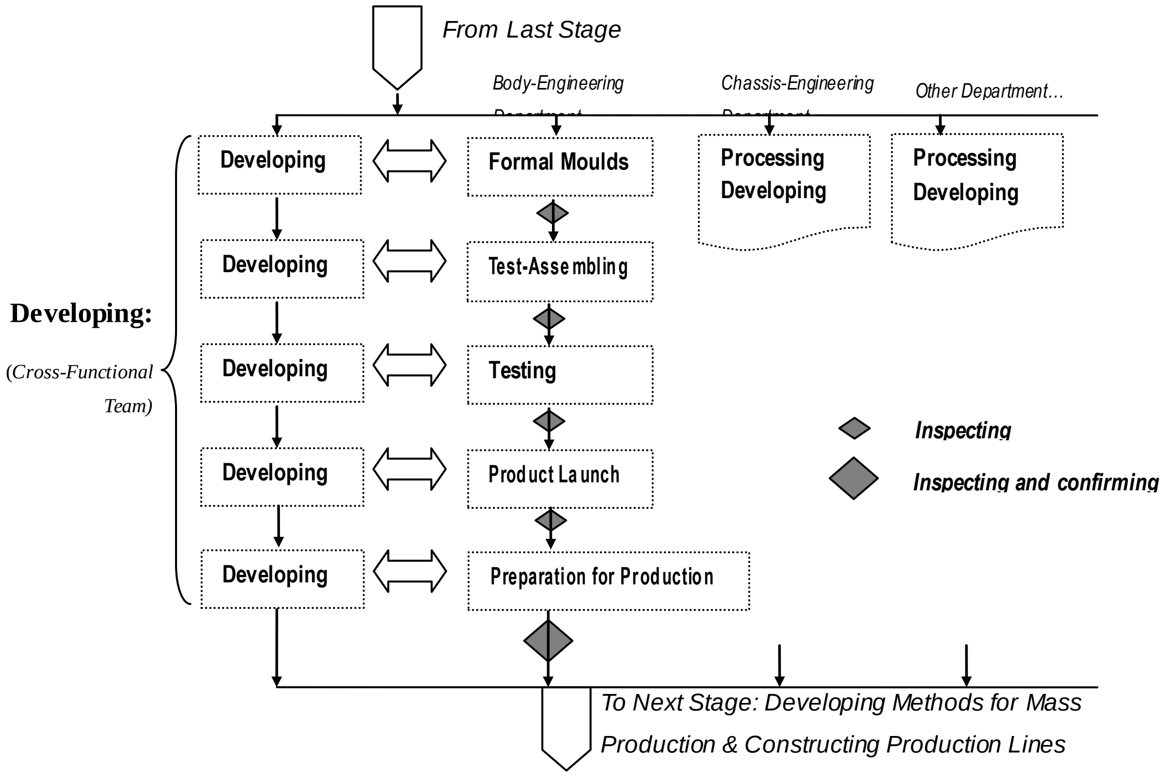
Note: Only the development of styling is highlighted with details in this picture.

Figure A-5.2 Technical Development Stage of product development in Group-B firms



Note: Only the developing of body-engineering is highlighted with details.*
***A-Surfaces mean the exterior faces of bodywork.*

Figure A-5.3 Industrialisation Stage of product development in Group-B firms



Note: Only the developing of body-engineering is highlighted with details

List of Interviewees

NAME	TITLE	ORGANISATION	NOTE
AN Jin	Vice Chairman; General Manager	JAC	
AN CongHui	Director of Board; Vice President; General Manager	Geely Hld.	
BAO QunLi	Engineer, CAD Centre	Geely Hld.	
CAO XiaoRong	Director, General Management Office	Chery Auto.	
CAO ShuMin	Vice President; Professorial Engineer	China Academy of Telecom Research, MII	
CAO Du	Director, Exterior & Interior Accessory Tech. Committee; Deputy Director, Commercial Vehicle Product Development Institute	Chery Auto.	
CAO XiangYing	Deputy Chief, Broadband Access Tech. & Product, Central R&D Department	Huawei Tech.	
CHE HaiPing	Senior Vice President; Director, Software Engineering Division	Huawei Tech.	
CHEN Hao	Engineer, Commercial Vehicle Product Development Institute	Chery Auto.	
CHEN Jesse	President	ATECH Automotive	ATECH is co-invested by Chery
CHEN Jian	Professor; Deputy Dean of Mechanical & Automotive Engineering School	HeFei Univ. of Tech.	
CHEN JinQiao	Director, Telecoms Policy Research Institute	China Academy of Telecom Research, MII	
CHEN Lei	Vice President in Manufacturing; Director of Management Board	Chery Auto.	
CHEN Wei	President	Xinwei Telecom	
CHEN WeiNong	Professorial Engineer; Secretary of Party Committee	CATRC	
CHEN YiLong	Professorial Engineer;	SAE of China	Also Secretary General, Automotive Industry S&T Progression Premium Foundation
CHENG Zheng	Senior Engineer, Product Department & Car Body Design Section, FAW Car	FAW	Chief designer of RedFlag platform from 1950s to 1990s
CHI Ye	Vice President; General Manager of Sales Company	Brilliance Auto	
CUI XueWen	President	HaFei Auto; HaFei Aircraft Industrial Group	
DAI MaoFang	Senior Engineer; Deputy General Manager	JAC	
DING ShiJin	Project Assistant, Program Management Department	Chery Auto.	
DING Yong	Director, Planning & Strategy Department of R&D Centre	Brilliance Auto	
DONG SiChun	Chief, Claim Section, Purchasing Quality Department	Chery Auto.	
DONG Feng	Director, Human Resources Department	Brilliance Auto	
DONG ChunBo	Director, R&D Centre	FAW	
FAN ShiWei	President of Planning & Design Institute	Chery Auto.	Ever worked in FAW
FAN BaoQun	Senior Economist	DRC	
FAN HongFu	Deputy Director, ZTE Tech. Centre	ZTE	
FANG YunZhou	Supervisor of AERI Clean & Efficient Energy Tech. Department, Automotive Engineering Research Institute	Chery Auto.	Ever worked in DongFeng
FANG WeiYi	Vice President	Huawei Tech.	
FEI JianFeng	Engineer	Shanghai-GM	
FENG WuTang	Assitant to President; General Manager of Engine Plant	Chery Auto.	Ever worked in FAW
FENG Ping	Deputy General Manager of Chery International	Chery Auto.	Ever worked in FAW

YANG	Yong	Engineer; Assistant to Director, Automobile Engineering Research Institute	Chery Auto.	
YANG	YiGang	Vice President	DTT; CATT	
YANG	JianZhong	Special Technical Adviser to CEO; Professorial Engineer [288]	Geely Hld.	Ever worked as Deputy Director of R&D Centre, FAW
YANG	Jian	Director of Board; Executive Vice President	Geely Hld.	
YANG	ZaiTian	Senior Manager, Development Strategy Committee	Xinwei Telecom	
YANG	BaoQuan	Chief, System Office	DongAn Engine	
YANG	GuiLiang	Vice President	DTT	
YIN	TongYao	President; Chairman of Board	Chery Auto.	Ever worked as Executive Vice President in FAW; Ever worked as Head of Assembly Workshop in FAW
YIN	BoBen	General Manager, HQ Automobile Manufacturing	Geely Hld.	
YOU	Yi	Senior Manager/Engineer, Engine Division	Brilliance Auto	
YU	YaJie	Quality engineer, PTEC Market Supporting Department	Chery Auto.	
YU	Wen	Assistant to Headmaster of Chery Univ.	Chery Auto.	
YU	Wei	Deputy General Manager, HQ Automobile Manufacturing	Geely Hld.	Ever worked as President of HuaLi Manufacturing, Tianjin Auto
YU	XueLiang	Director, Administration Department	Geely Hld.	
YU	BaoCheng	Senior Engineer;	Chery Auto.	Ever worked in FAW
YU	YaJie	Engineer; Product Improvement Department	Chery Auto.	
YU	Ting	Director of Engine Plant	Geely Hld.	Ever worked in Ministry of Railway
YUAN	YongBin	Vice President, Automotive Engineering Research Institute	Chery Auto.	
YUAN	Hong	Manager of Haise Model	Brilliance Auto	
YUAN	Tao	Vice President in Purchasing	Chery Auto.	
ZENG	QingHua	Director, Quality Tech. Department, Quality Assurance Department	Chery Auto.	
ZENG	GuoHua	Chief, Chassis Department, Passenger Vehicle Product Development Institute	Chery Auto.	Ever worked in Shanghai-Volkswagen
ZHA	jianPing	Vice President	Brilliance Auto	
ZHAN	LiangSheng	Deputy Director, Program Management Department	Chery Auto.	
ZHAN	WanJin	Vice President in Sales	Geely Hld.	Ever worked in FAW as Vice President
ZHAN	XiaLai	Mayor; Secretary of Municipal Party Committee	WuHu City	Ever worked as Chairman of Board, Chery.
ZHANG	Lin	General Manager, Chery International	Chery Auto.	
ZHANG	LiMin	Senior Engineer, Technical Equipment Office	WFIERI	
ZHANG	ZuoYang	Senior Engineer; Vice-dean of Automotive Tech. Academy	JAC	
ZHANG	Ping	Executive Vice President; Director of Management Board	Chery Auto.	
ZHANG	FaQiang	Manager, Human Resources Department	Chery Auto.	
ZHANG	GuoZhong	Chairman, Labour Union; Director, No.2 Car Plant	Chery Auto.	
ZHANG	YaFeng	Assistant to President; Vice President, Planning & Design Institute	Chery Auto.	
ZHANG	[illegible]	Deputy Chief, CAE Department, Passenger Vehicle Product Development Institute	Chery Auto.	

Note: (1) In this list, only names of interviewees with whom the author ever had more than 2 hours' conversation are included while other interviewees are not counted in. Even for the names of some with over 2 hours' conversation have been lost. Thanks to them all.

(2) Chery and Xinwei allowed the author to carry out investigation by the way of participation with their uniforms. Many interviews were carried out as "casual" conversations in workshops, conference rooms, dining rooms, sports fields, laboratories, and their dormitories, or happened in their negotiations with customers and even the field working. For better interview effects, the author did not disclose his name, and did not have the names of some of these interviewees. Thanks to them.

(3) Titles of interviewees list here were the positions of them as the time of interviews. For interviewees who I ever had more than one interviews with, their recent positions are listed, unless special notes are made.

(4) The interviews with JiangXing Wu and GuoYing Lu (core leaders of HJD series development) were carried out by Feng Lu in 2003. Feng Lu had a special conversation and discussion with me about the interviews, and shared with me his original interview notes, as we were partners in a project at that time. These two interviewees are not listed in the table. But I express my special appreciation to Feng Lu for his generous helps.

(5) Abbreviations in this table: CATRC: China Automotive Technology and Research Centre; CCID: China Centre for Information Industry Development; DRC: Development Research Centre of the State Council, China; Geely Hld.: Geely Holding Group; JAC: AnHui JiangHuai Automotive Co., LTD; WFIERI: Wuxi Fuel Injection Equipment Research Institute, FAW

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