University of Sussex

School of Engineering and Informatics

Department of Engineering and Design

Doctor of Philosophy in Engineering

12 July 2016

Thesis Title:

Evolving Brunei Darussalam's Economy Towards Technology-Based Industries

Originator : Mohammad Sofian Bin Haji Awang Radzuan
Student Number : 21114264
Date of Admission : January 2012
Supervisor : Professor Chris R Chatwin

Presented by:

Mohammad Sofian Haji Awang Radzuan

Degree of Doctor of Philosophy in Engineering

Thesis

Supervisors:

Professor Chris R Chatwin

Dr R Young

This research report is submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy in Engineering in the School of Engineering and Informatics, Department of Design and Engineering, the University of Sussex, United Kingdom. I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

12 July 2016

Table of Contents

S.No	Contents		Page No

ABSTRACT

Technology-Based Industries continue to be at the forefront of a nation's sustainable economic development. These account for the largest share of employment, business activity and labour income in most primary sectors. Technology-Based Industries contribute to multi-lateral development of a nation's economy through innovation, new technologies and use of new knowledge. The government of Brunei Darussalam sought in the past decade to diversify the economy with limited success. Oil and gas and government spending still account for most of Brunei's economic activity. The small size of the domestic market discourages foreign direct investment in Brunei Darussalam. Brunei's government encourages foreign investment especially when it involves emerging new technologies and technology transfers. The research question is: how to transfer new technologies into Brunei Darussalam industry and to quantify the impact of these Technology-Based Industries; can a resource based-economy offer a solution to tackle the difficulties in industrial advancement that Brunei Darussalam is currently struggling with.

This research aims to study factors for the successful transfer of technology-based industries and identify the key issues in technology transfers that significantly affect the rate of technological integration and evaluate the concept of technology transfers and its contribution to the sustainable economic development of a small state economy. It adopts multiple techniques both inductive and deductive approaches through SWOT-analysis and case studies to explore and later analyze the importance of the visionary drive underlying the technology-based industrial strategy that contributes to policy improvement, via awareness of alternatives and discovery of latent policy constraints and opportunities from investigation of others' experience. The bottom line of this research is to provide the basis for government policies on how the technology transfer can be achieved in the Brunei Darussalam industrial context.

KEY WORDS: technology-based industry, foreign direct investment, technology transfer, SWOT-analysis, case study

ACKNOWLEDGEMENTS

My heartfelt gratitude to my research supervisor Professor Chris R Chatwin for his motivation, continuous support and immense knowledge. His unfailing intellectual guidance helped me during the time of research and also in the write up of this thesis but also for the hard question which incentivized me to widen my research to many different perspectives. I could not have imagined having a better supervisor for my research endeavor. Your advices have been extremely priceless. I thank my second supervisor Dr R Young for his encouragement, precious support and insightful comments. Also, my fellow research students who supported me in writing and encouraged me to strive towards my goal and others who have had helped me indirectly. I am greatly indebted to Dr Akhbar for his helped in the presentation of my thesis.

My special thanks to the University of Sussex for the opportunity to expand my intellectual faculty through my five years of research endeavor; to learn and grow fully in the academic field, and to the Government of His Majesty, the Sultan of Brunei Darussalam through the Public Service Commission, the Prime Minister Office, who allocated funding and all other necessary financial supports both to meet my academic needs and daily necessities while attending the In-service Training in the United Kingdom. Lastly, I thank my family for their inspiration and for being so close to me always. Words cannot express how grateful I am to them. Their prayers for me were what sustained me thus far. Undoubtedly, this thesis would not been possible to conclude without this support from all concerned.

ABBREVIATIONS

Association of South-East Asian Nation	ASEAN
Asia-Pacific Economic Co-operation	APEC
Brunei Economic Development Board	BEDB
Business Advisory Council	ABAC
Continuous flow manufacturing	CFM
Computer integrated manufacturing	CIM
Economically active population	EEAP
Environmental impact assessment	EIA
Environmentally sound technologies	ESTs
Foreign direct investment	FDI
Gross domestic product	GDP
Human development index	HDI
Industrial development plan	IDP
Information and communication technology	ICT
International monetary fund	IMF
Just in time manufacturing	JIT
Knowledge Engineering	KE
Knowledge Management	KM
Less developed countries	LDCs
Newly industrialized countries	NICs
Organization for Economic Co-operation and Development	OECD
Research and technical development	RTD
Research and Development	R&D
Return on investment	ROI
Small and medium enterprises	SMEs
Small state economy	SSE
Special economic zone	SEZ
Trade and Investment Framework Agreement (TIFA)	TIFA
Technical and vocational education	TVE

List of Tables

List of Figures

CHAPTER 1:

GENERAL OVERVIEW

1.1 Summary

Brunei's main economic problems include rising unemployment especially among fresh graduates, huge state subsidies, a civil service which employs around 75% of Brunei's workforce, extensive state economic controls, a chronic and worsening budget deficit, a small tax base and a heavy reliance on the hydrocarbons sector. The government of Brunei Darussalam is looking into ways to diversify away from a heavy reliance on hydrocarbons into areas including tourism, financial services, hi-tech and energy-intensive industries. The government has set out the directions for its economic goals with a growing emphasis on attracting foreign direct investments as an important driver of growth, focusing mainly on economic activities that bring new knowledge, new industries, new technologies, new markets as well as new business and employment opportunities for its people. The emerging new technologies are one area that the government is interested in.

1.2 Aims and Objectives

The technology transfer process faces: economic, political, financial, technological, information, institutional and cultural barriers. It is essential to emphasize that technology transfer efforts need to focus on accumulation and development of technological capabilities to support long-term economic development. This research aims to study factors for the successful transfer of technology-based industries, identify key issues for technology transfers that significantly affect the rate of technological integration and evaluate the concept of technology transfer and its significant contributions to the sustainable economic development of a small state economy (SSE) i.e. nations with a population under 1.5 million (World Bank), Brunei Darussalam has a population of less than 1.5 million. Brunei Darussalam needs to identify foreign markets for growth strategies. The research question is how to bring in new technologies into Brunei Darussalam industry and to verify scientifically the impact of these Technology-Based Industries. Can a resource based-economy (where a nation's gross national product or gross domestic product extensively comes from natural resources)[1] offer solutions to tackle difficulties in industrial advancement that Brunei Darussalam is currently struggling with. Brunei has failed to bring in foreign direct investments (FDI), i.e. investment made by an external firm that controls ownership in a business enterprise in one country by an entity based in another country[2], which is a prime driver for technology transfer. Foreign direct investment is the sum of equity capital, reinvestment of earnings and other capital that involves participation between management, expertise, joint-venture and transfer of technology.

Transfer of Technology (TOT) or technology transfer is the process of transferring skills, knowledge, technological methods of manufacturing, samples of manufacturing and facilities among governments or higher academic institutions and other authorities to ensure that scientific and technological developments are acceptable to a wider range of users who can then further develop and exploit the technology into new products, processes, application of materials or services. Transfer of technology is more than just the moving of hi-tech equipment from the developed to the developing world, or within the developing world. It encompasses far more than equipment and other so-called hard technologies, for it also includes total systems and their component parts, including know-how, goods and services, equipment and organizational and managerial procedures. Thus, technology transfer is the suite of processes encompassing all dimensions of the origins, flows and uptake of know-how, experience and equipment amongst, across and within countries, stakeholder organizations and institutions. If the transfer of inadequate, unsustainable or unsafe technologies is to be avoided, technology recipients should be able to identify and select technologies that are appropriate to their actual needs, circumstances and capacities. Therefore, a key element of this wider view of technology transfer is choice. There is no single strategy for successful transfer that is appropriate to all situations. Desirably, a technology recipient will choose a technology which at least meets the definition of being environmentally sound.

Environmentally Sound Technologies (ESTs) are technologies that have the potential for significantly improved environmental performance relative to other technologies. These technologies protect the environment, are less polluting, use resources in a sustainable manner, recycle more of their wastes and products, and handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes. Preferably a technology recipient will go even further, and select a sustainable technology – i.e. a technology that is not only environmentally sound but also economically viable and socially acceptable[3]. Transfer of technology is closely related to innovation[4]. Innovation is defined as a new idea, device or method[5]. However, innovation is often also viewed as the application of better solutions that meet new requirements, unarticulated needs or existing market needs[6]. This is accomplished through more-effective products, processes, services, technologies or business models that are readily available to markets, governments and society. The term innovation can be defined as something original and more effective and, as a consequence, new, that breaks into the market or society[7]. Industrial innovation needs an even broader perspective that moves towards service-dominant logic. The science, technology or corporate-driven innovation paradigm has been challenged by a new open, human and ecosystem-based collaborative innovation paradigm. Open economies with skilled workforces and good growth prospects tend to attract more foreign direct investment in contrast with closed highly regulated economies. What are roles of engineering and technology in advanced businesses from Brunei's perspectives that encourage the integrated technological transfer system to support high-tech infrastructure and development drive potentially Brunei Darussalam possesses to enable advances in its industrial sectors. Significantly, the integrated engineering paired with a keen understanding of business processes will result in a better control of technology which is the key to a sustainable industrial climate. It is fully understood that almost all international business agreements contain provisions on technology transfer and the various legislations such as the Patent Act (Brunei's legislation that controls the use of patents) facilitate the public setting for its use. It is necessary to study the concept of technology transfer in order to identify and fully observe its long-term returns. The development of industrial sectors is a key driver of development while the transfer of technology is an essential requirement for the development of domestic industries. Technology transfer is the essential part of the entire research priority. Thus, special attention is focused on this area while simultaneously analyzing and evaluating all collective data. The key questions framing this study are the significant importance of technology transfer and the need to shift from hydrocarbon-based industry to high-tech industry, its theoretical ideas and technological developments.

Modern manufacturing industry requires the application of technological developments and efficient management of resources. Having the right process and implementation makes the difference between delivering against cost, quality and volume targets or never achieving the required performance objectives. Technology improves products and/or processes with the relevant technology being described as advanced, innovative or cutting edge. The rate of technology adoption and the ability to use that technology to remain competitive and add value define the advanced manufacturing sector[8]. Advanced manufacturing centers improve the performance of many industries through the innovative application of technologies, processes and methods to product design and production. A survey of advanced manufacturing definitions by the White House states: "A concise definition of advanced manufacturing offered by some is manufacturing that entails rapid transfer of science and technology (S & T) into manufacturing products and processes" (PCAST, April 2010). Eventually, a successful industrial performance relies primarily on the complete integration of technological developments and resources into the whole manufacturing system.

1.3 Issues of Economic Growth and Statement of Problems

Brunei Darussalam is a wealthy economy with per capita gross domestic product (GDP) US$49,384 and purchasing power parity (PPP) US$20.969 billion in 2011[9], this is far greater than most other Association of South-East Asian Nation (ASEAN) member countries, mainly due to a positive growth in the hydrocarbon-based industry with relatively small population[10]. According to the International Monetary Fund (IMF), Brunei Darussalam is ranked 5th in the world by gross domestic product per capita at purchasing power parity. Forbes also ranks Brunei as the 5th richest nation out of 182 nations due to its extensive petroleum and natural gas fields[11]. Brunei Darussalam experienced rapid economic growth during the 1970s and 1990s, averaging 56% from 1999 to 2008 has transformed the state into a newly slow-growing industrialized country. It has the second highest human development index (HDI) among the ASEAN member nations after Singapore and is classified as a developed country[12]. The 2011 Human Development Report was released on 2nd November 2011 and calculated the human development index values based on estimates for 2011 ranked Brunei Darussalam 33rd on its list of the very high human development countries. The human development index is a summary measure of average achievement in key dimensions of human development; a long and healthy life, achieve a good level of education and enjoy a decent standard of living. The health dimension is assessed by the life expectancy at birth, the education dimension is measured by mean of years of schooling for adults and expected years of schooling for children of school admission age. The standard of living dimension is measured by the gross national income per capita. The population of Brunei Darussalam in July 2011 was 401,890 and the average life expectancy is 76.4 years. Brunei Darussalam is a South-East Asian country consisting of two unconnected parts with the total area of 5,765 square kilometers (2,226 sq mi). It has 161 kilometers (100 mi) of coastline next to the South China Sea and it shares a 381 km (237 mi) border with Malaysia. It has 500 square kilometers (193 sq mi) of territorial waters and a 200 nautical mile exclusive economic zone[13].

Brunei Darussalam derives most of its income from the exports of oil and gas. It is the third largest oil producer in South-East Asia (after Indonesia and Malaysia) and the fourth largest producer of liquefied natural gas in the world. Crude oil and natural gas production account for about 90% of its gross domestic product (GDP). About 167,000 barrels of oil are produced every day. It also produces approximately 895 million cubic feet of liquefied natural gas per day, making Brunei Darussalam the ninth-largest exporter of the substance in the world. Substantial income from overseas investments supplements income from domestic production. Most of these investments are made by the Brunei Investment Agency (BIA), an arm of the Ministry of Finance[14]. The Brunei Investment Agency is a government-owned investment organization that manages the sovereign wealth fund for Brunei Darussalam. In 2009, the US State Department estimated Brunei Investment Agency has approximately US$30 billion in assets under management. The funds deposited with the Brunei Investment Agency are primarily the surplus revenues from the development of Brunei's hydrocarbon reserves. Brunei Darussalam depends heavily on imports such as agricultural products, for example: rice, food products, livestock, etc., motorcars and electrical products from other countries. The state imports 60% of its food requirements, with around 75% of those food imports coming from the ASEAN countries[15].

Brunei's main import partners are Singapore, Malaysia, China, Japan, the United States and Germany. Imports to Brunei Darussalam increased to US$282.4 million in January 2016 from US$217.07 million in the same month of the previous year as imports of mineral fuels (+2523.1%), manufactured goods (+86.6%) and beverages and tobacco (+36.4%) went up. Imports in Brunei averaged US$327.8 million from 2005 until 2016, reaching an all time high of US$857.3 million in September of 2008 and a record low of US$151.3 million in March of 2014. Imports in Brunei Darussalam are reported by the Department of Economic Planning and Development, Brunei Darussalam. Brunei's leaders are very concerned that steadily increased integration into the world economy will undermine the internal social cohesion, nevertheless, it became a more prominent player by serving as the chairman for the 2000 Asia-Pacific Economic Cooperation (APEC) forum. The government's future plans include upgrading the labor force and reducing the unemployment rate which decreased to 6.9% in 2014 from 9.3% in 2011. Unemployment rate in Brunei Darussalam until 2014, reaching an all time high of 9.3% in 2011 and a record low of 2.9% in 2010 of Brunei's total population[16]. This is being addressed by strengthening the banking and tourism sectors and, in general, further widening the nation economic base. Brunei Darussalam plans to boost its financial sector by launching its own stock exchange and will drop off the international list of countries without a stock exchange. The stock exchange will boost the nation's financial industry and provide an alternative funding source for small and medium businesses (SMEs) and strengthen Brunei's corporate governance. The government is increasing efforts to promote Brunei Darussalam as a destination for upscale tourism and ecotourism. The United States goods trade surplus with Brunei Darussalam was US$541 million in 2013. Brunei Darussalam currently stands as 121st largest goods trading partner to the United States with US$576 million in total (two ways) goods trade during 2013. Goods exports totaled US$559 million while goods imports totaled US$17 million. Brunei Darussalam was the United States' 100th largest goods export market in 2013. The United States goods exports to Brunei Darussalam in 2013 were US$559 million, up 254.4% (US$401 million) from 2012, and up 1,389% from 2003. The top export categories (2-digit HS) for 2013 were: Aircraft (US$399 million), Machinery (US$64 million), Optic and Medical Instruments (US$23 million), Special Other (low value shipments) (US$18 million), and

Electrical Machinery (US$16 million). The United States exports of agricultural products to Brunei Darussalam totaled US$6 million in 2013. Brunei Darussalam was the United States' 160th largest supplier of goods imports in 2013. The United States goods imports from Brunei Darussalam totaled US$17 million in 2013, an 81% decrease (US$69 million) from 2012, and down 96% from 2003. The top five imports categories (2-digit HS) for 2013 were: Organic Chemicals (US$7 million), Special Other (returns) (US$4 million), Knit Apparel (US$3 million), Fish and Seafood (shrimp and prawns) (US$2 million), and Woven Apparel (US$758 thousand). There were no United States imports of agricultural products from Brunei Darussalam in 2013. The United States goods trade surplus with Brunei Darussalam was US$541 million in 2013, up 658.8% (US$470 million) from 2012. The United States foreign direct investment (FDI) in Brunei Darussalam (stock) was US$116 million in 2012, up 17.2% from 2011 and Brunei Darussalam has no external debts. Furthermore, the industrial production growth rate for Brunei Darussalam until January 2011 was recorded as negative 5.4%, to position Brunei Darussalam placing it at 163rd ranked country, which makes it one of the slowest industrial developing states in the world. Brunei Darussalam and the United States are partners in the ongoing Trans-Pacific Partnership (TPP) negotiations. In this negotiation, the United States is seeking to develop a high standard, 21st century regional trade agreement that will support the creation and retention of jobs in the United States and promote economic growth. The United States and Brunei Darussalam meet regularly under a Trade and Investment Framework Agreement (TIFA) to address a range of bilateral issues and to coordinate on World Trade Organization (WTO), Association of South-East Asian Nation (ASEAN), and Asia-Pacific Economic Cooperation (APEC) initiatives. Intellectual property rights (IPR) continues to be a major focus of current United States engagement with Brunei Darussalam. In 2011, the European Union total trade in goods with Brunei Darussalam was US$1.32 billion making the European Union as Brunei's 4th largest import partner that provide 13% of Brunei's total imports. The EU's key exports to Brunei Darussalam are commodities and transactions comprising 82.8%. Brunei's key export items to the European Union include machinery and other manufactured products. There were considerable fluctuations in the values of exports and imports between Brunei Darussalam and the European Union. However, there was a persistent negative balance of trade for Brunei Darussalam throughout that period. Bilateral trade flows (both imports and exports) between Brunei Darussalam and the EU members were driven mainly by the populations of Brunei Darussalam and the EU countries.

The literacy rate for adult Bruneians aged fifteen and above in 2009 was 95.29%, the population growth rate was at 1.71% and the labor force for Brunei Darussalam stands at 188,000 in January 2011. There were more than 110,000 students in its education system in 2007 with more than 270 educational establishments throughout Brunei Darussalam comprising of both government administrated and private institutions. Education is provided free up to the university level and beyond for Brunei citizens. The education provided aims to produce young Bruneians who are able to play a vital role in the present day knowledge-based economy. Around 52% of young children are enrolled in pre-primary schools, and 94% of children are enrolled in primary schools, with a 100% completion rate for primary education annually. Around 90% of children attend secondary school, although 5% more girls than boys are enrolled. At the university level, only 15% of students attend. Nearly four times more women than men receive degrees from university annually. Brunei's educational plan for the 2012-17 focused on three areas: teaching and learning excellence; professionalism and accountability; and efficiency and innovation, all bolstered by the fourteenth strategic objectives and the eighteenth key performance indicators. Complementing the transformation of its basic education system is an equally ambitious overhaul of tertiary institutions designed to combat unemployment across a broad range of sectors and skill sets. The sector benefits from substantial funding. Complementing the broader restructuring of the primary education system to redirect its focus towards meeting the needs of a modern, knowledge-based economy is a separate reboot of the technical and vocational education subsector (TVE). Given its importance in reducing unemployment and placing more Bruneians in key growth industries, the overhaul of the TVE subsector is a key component of both the National Education System for the 21st Century Plan (as one of its the three core priorities) and the Brunei Darussalam Vision 2035, which calls for greater development of technical skills. If successful, the reforms should allow the Sultanate to maximize the potential of its limited labor pool and reduce its reliance on foreign workers in many sectors ranging from offshore oil and gas rig engineering to travel and tourism services. In the 2014-15 budgets, for example, the Ministry of Education received the second largest allocation of any state entity at US$448.61 million or 13% of the total. Brunei Darussalam has three higher education institutions and eight technical colleges that provide degree, advanced diploma and diploma programmes to produce educated and skilled young Bruneians[17].

Brunei's main economic problems include rising unemployment especially among fresh graduates, huge state subsidies, a civil service which employs around 75% of Brunei's workforce, extensive state economic controls, a chronic and worsening budget deficit, a small tax base and a heavy reliance on the hydrocarbons sector. Brunei Darussalam is looking into ways to diversify away from a heavy reliance on hydrocarbons into areas including tourism, financial services, high-tech and energy-intensive industries. Brunei Darussalam has proven crude oil reserves of 1.4 billion barrels in 2000 unless new discoveries are made via deep sea exploration, which is expected to contribute significant new reserves. Current production averages 191,000 barrels per day (bbl/d) of mainly low-sulfur oil, plus around 22,000 bbl/d of natural liquefied gas. This is down from peak production (of around 250,000 bbl/d) reached in 1979. Brunei's oil production peaked in 1979 at more than 240,000 bbl/d, but was cut back deliberately to extend the life of the fields and to improve the recovery rates. The country's economy enjoyed moderate growth in the mid-2000s, primarily due to high world oil and gas prices but the growth has fallen sharply in recent years. In 2009, GDP shrank from US$15.6 billion to US$12 billion. Brunei Darussalam continues to have one of the lowest GDP growth rates of any ASEAN nation but Brunei Darussalam is also ranked as having one of the highest rates of macroeconomic stability in the world and the highest in Asia. Brunei's conservative economic policies insulated it from much of the global financial crisis between 2008 and 2009. Brunei's oil reserves are expected to last 25 years and the natural gas reserves 40 years. However, new technology and potential onshore and deep sea fields are expected to add to the lifespan of these reserves[18].

The government sought in the past decade to diversify the economy with limited success. Oil and gas and government spending still account for most of Brunei's economic activity. Brunei's non-petroleum industries include agriculture, forestry, fishing, aquaculture and banking. The Brunei Economic Development Board (BEDB) announced plans in 2003 to use the proven gas reserves to establish downstream industrial projects. In 2006, the Brunei Methanol Company, a joint venture between Petroleum Brunei, Mitsubishi and Itochu, was established. The US$400 million methanol plant, fed by natural gas, came on line in 2010. The plant has the capacity to produce 2,500 metric tons of methanols per day. The government has plans to build a power plant in the Sungai Liang region to power a gas-based petrochemical plant and other downstream industries that will depend on foreign investors. A second major project depending on foreign investment is on Pulau Muara Besar (PMB). In July 2011, BEDB announced the establishment of a US$2.5 billion oil refinery and aromatics cracker project on the Pulau Muara Besar. The government encourages foreign investment in Brunei Darussalam. New enterprises that meet certain criteria can receive pioneer status, exempting profits from income tax for up to five years, depending on the amount of capital invested. The normal corporate income tax rate is 30%. There is no personal income tax or capital gains tax. However, foreign direct investment (FDI) outside the oil and gas industry remains limited[19].

The reduced size of the domestic market discourages Foreign Direct Investment (FDI) in Brunei Darussalam, despite the advantages offered by the Sultanate: tax incentives and customs duties exemptions on certain sectors, especially non-oil investments; freedom of investment in all sectors with the exception of certain fields in which local participation is required. Since 2011, Foreign Direct Investment inflows have been growing considerably. According to the World Bank (2015 Doing Business ranking), Brunei ranked 101st out of 189 in terms of its business climate, which means a significant decline. However, a study of the APEC Business Advisory Council (ABAC) published in 2013 gave a mixed judgment in terms of the country's business climate in several domains (citing the absence of a Special Economic Zone (SEZ), bureaucratic problems for investors, etc.). The term Special Economic Zone is commonly used as a generic term to refer to only one modern economic zone. In these zones business and trade laws differ from the rest of the country. Broadly, SEZs are located within a country's national borders. The aims of the zones include: increased trade, increased investment, job creation and effective administration. To encourage businesses to set up in the zone, financial policies are introduced. These policies typically concern investing, taxation, trading, quotas, customs and labor regulations. Additionally, companies may be offered tax holidays. The creation of special economic zones by the host country may be motivated by the desire to attract foreign direct investment (FDI). The benefits a company gains by being in a Special Economic Zone may mean it can produce and trade goods at a globally competitive price. The operating definition of an economic zone is determined individually by each country. In some countries the zones have been criticized for being little more than Chinese labor camps, where labor rights are denied for workers. In order to increase transparency and strengthen corporate governance, the Company Act was amended in January 2015. The new version aims to simplify the business climate. The corporate tax rate also decreased in 2015 and is now the second lowest among the ASEAN countries (18.5%). The largest foreign investment accomplished to this day is a methanol distillery, partially financed by the Japanese Mitsubishi Gas Chemical Company. China is also present in the hydrocarbon sector and a large-scale investment project has been studied since 2013. The government has been making an effort to diversify the economy and turn Brunei Darussalam into a banking centre as well as an international offshore financial hub. Foreign Direct Investment; net inflows (% of GDP) in Brunei Darussalam was last measured at 5.56 percent in 2013 according to the World Bank. Foreign Direct Investment is the net inflows of investment to acquire a lasting management interest (10% or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long term capital and short term capital as shown in the balance of payments. This series show net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors and is divided by GDP. Foreign direct investment in Brunei Darussalam and other countries reflects the foreign ownership of production facilities. To be classified as foreign direct investment, the share of the foreign ownership has to be equal to at least 10 % of the value of the company. The investment could engage in manufacturing, services, agriculture or other sectors. It could have originated as green field investment (building something new), as acquisition (buying an existing company) or joint venture (partnership). **Brunei Darussalam Foreign Direct Investment (FDI) % of GDP**; for that indicator, the World Bank provides data for Brunei Darussalam from 2001 to 2013. The average value for Brunei Darussalam during that period was 3.12 % with a minimum of 0.77 % in 2006 and a maximum of 7.24 % in 2011.

The government of Brunei Darussalam, through its 2035 vision, has set out the directions for its economic goals with a growing emphasis on attracting foreign direct investments (FDI) as an important driver of growth, focusing mainly on economic activities that bring new knowledge, new industries, new technologies, new markets as well as new business and employment opportunities for its people. The economic strategy that has been established calls for;

i. Ensuring continued macroeconomic stability
ii. Ensuring high rates of economic growth
iii. Promoting national economic competitiveness through policies that encourage productivity, economic openness and competition
iv. Investing in downstream oil and gas industries, and other economic clusters selected on the basis of Brunei Darussalam's competitive strengths, export potential and employment opportunities for local people
v. Investing in the world class infrastructure that is required to attract foreign and domestic investment in the new export industries

The emerging new technologies are another area that the **government is interested in.** An emerging technology contains some of the most prominent ongoing developments, advances, and innovations in various fields of modern technology. Emerging technologies are technical innovations that represent progressive developments within a field for competitive advantage. These are contemporary advances and innovation in various fields of technology. Over centuries, innovative methods and new technologies are developed and opened up. Some of these technologies are due to theoretical research and others from commercial research and development. Promoting emerging technologies is an increasingly high priority for governments around the world. Stimulus packages, market incentives and massive funding of technology development in the lab are defining future winners and losers at a country level today. The key for any government level initiative is to understand emerging technologies and how they will impact important local industries. Emerging technologies are key drivers for future prosperity because they help provide the foundation for innovation to occur. An innovative economy continually takes advantage of new technologies, new ideas, new trends and new market opportunities to build successful companies and industries. Innovation is the process by which new economic and social benefits are extracted from knowledge. Emerging technologies represent the leading edge of innovation as technical innovation is critical for sustained economic development. In a move to position Brunei Darussalam as a new technology player in the next twenty to thirty years, the Brunei Economic Development Board (BEDB) is currently looking into the feasibility of bringing new frontiers of science and technologies into Brunei Darussalam to create economic activities that are driven by accelerated technology developments that have increasingly significant economic value. The potential new technologies may be found within the identified sectors of health care and or health sciences, food security, advanced manufacturing processes, material sciences and electronics as well as further research into the areas of energy, sustainable environment and ICT. The exploration of Brunei's hydrocarbon is extensively relying on external expert that ICT has more potential to further develop and higher educational establishments can play a significant role in educating and implementing skills in the petro-chemical field. Brunei Darussalam is a country of enviable political and economic stability where a serene and secure social environment prevails. The government recognizes that oil and gas are non-renewable commodities; the country is now embarking on a diversification programme with emphasis on industry and commerce. Brunei Darussalam has drawn up an Industrial Development Plan to help the country diversify its oil-based economy. The non-oil sectors of the economy include manufacturing, services and trade, tourism and advanced technology. With a long history of oil and gas production, Brunei Darussalam is now looking to open up new frontiers and develop capabilities in the field of renewable energy. Abundant deposits of silica sand available in Brunei Darussalam have been seen as conducive to the development of a hub for solar glass manufacturing as well as solar cells and modules production. The solar glass business is very profitable, boosted by growth in the solar market. As traditional companies do not offer a business model that is suitable to PV companies, we will see more new entrants to this competitive market, solely dedicated to solar glass and mirrors. In 2007, 138 million tons of glass was produced. Of this, 50 million tons were flat glass, which is used in solar modules and reflectors. The flat glass market is worth US$23.79 billion annually. Some glass is further processed by laminating, tempering, coating and silvering, making this a market of US$60 billion annually. Growth has generally outpaced real GDP growth, boosted by demand from automotive and construction sectors in China, but also by extending the use of glass to new innovative applications. The flat glass market alone is predicted to grow by 5% annually. There is a regional imbalance between the demand and supply for flat glass. While China produces more glass than it consumes, Europe and the Middle East, and to a lesser extent North America are net importers of glass, despite the relative high transport costs for glass. This imbalance stems probably from the high cost of energy which is a large part of glass manufacturing in Europe[20].

1.4 Silica Sands

The Ministry of Development, Brunei Darussalam, commissioned the Federal Institute for Geosciences and Natural Resources (BGR), to access (initial study) silica sand occurrences in the coastal region of Brunei Darussalam (government letter dated 20th April 1987 ref.KPN/IDU/4.12/86). A total of seventy five quartz samples were taken to be analyzed and the melting properties of the quartz sand were tested on five samples. Only twenty five samples were actually analyzed in the BGR Chemical and Sediment-Petrography Laboratory, Hannover, Germany, for their grain sizes. The results of the twenty five analyses and general comparative data on glass sands were submitted to the Ministry of Development, Brunei Darussalam (on 16th September 1987 and 20th October 1987). A final report based on grain sizes and chemical analysis of a first series of only twenty five silica sand samples was completed on 15th December 1987. BGR was further commissioned to carry out an additional twenty five grain size and chemical analyses by the concerned government authority in Brunei Darussalam[21]. This early assessment made by BGR stated that the Tutong silica sand deposit forms a terrace with an average elevation of fifteenth meters above sea level, this extends ten kilometers from the Tutong River in the east to Telamba Village in the west **(Figure 1.1)** covering an area of approximately 4 Km^2. The silica sands have a very low nutrient content and thus the terraces are largely devoid of vegetation except for shrubs and stunted trees.

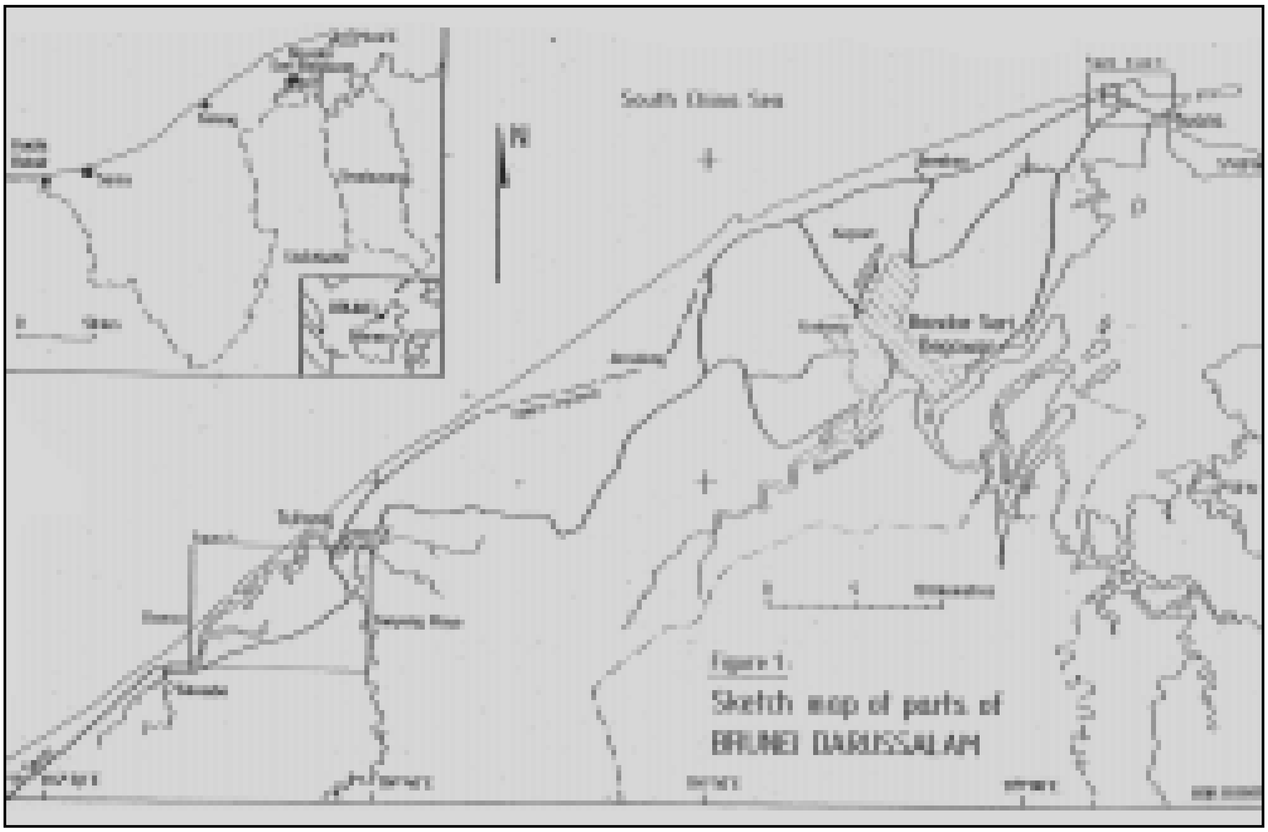

Figure 1.
Sketch map of parts of BRUNEI DARUSSALAM

1.5 Characteristics of Silica Sands

At time samples were collected, importance was attached to their being distributed as evenly as possible over the entire deposits. BDR commented that the mean SiO_2 content of 98.88wt.-% is too low to qualify the Tutong silica sands as high-grade glass sand but there is the possibility to increase the SiO_2 content to much more than 99wt.-% through a suitable refining process and to drastically reduce the content of detrimental oxides including Fe_2O_3, TiO_2 and CrO_3. High quality raw silica sand is excavated selectively with a high content of SiO_2, required grain size and low content of impurities. This is monitored and controlled by routine analysis for all sand deliveries. The normal processing method for silica sand is carried out in four stages including washing, sieving, attrition and drying to produce industrial white silica sand having an extraordinarily high purity, with SiO_2> 99.5wt.-%. The grain size ranging from 0.125 to 3.00 mm indicating that it is not of high grade but most modern high technology sieving facilities can provide different size distributions for different requirements.

The definition of glass sand is subject to opinion and this is particularly the case with respect to its chemical composition. Glass sand is a virtually pure, fine to medium grained silica sand. The definition on the basis of grain size has proven useful in the industry. For example; 95wt.-% of the grains passing a 0.600-mm sieve and essentially 100wt.-% retained on a 0.104-mm sieve. Therefore, various screens were used for grain size analysis in the BGR Chemical and Sediment-Petrography Laboratory. In accordance with the mentioned definition and the opinion of the German glass industry, the 0.112 to 0.630-mm fraction (0.112 to 0.200-mm, 0.200 to 0.355-mm and 0.355 to 0.630-mm fractions) is regarded as the fraction most suitable for glass production. Most of the Tutong silica sand is in the 0.112 to 0.630-mm grain size range, as desired by the glass industry. A great advantage is the fact that there is a distinct concentration in the 0.112 to 0.200-mm and 0.200 to 0.355-mm fractions. Of particular disadvantage is the considerable variation of the grain size distribution from sample to sample but a consistently uniform grain size composition can be obtained by suitable beneficiation methods. The roundness of the quartz grains of the Tutong silica sand is moderate to poor. The samples of near surface silica sands indicate comparatively high TiO_2 and Cr content, from which it can be concluded that the Tutong silica sand has a significant mineral content that is high. Fusion tests on five samples showed that the resulting glass has a greenish tint, caused by the heavy mineral chromites. For this reason the BGR recommended that the Tutong silica sands should be processed using a suitable floating method for separating the heavy minerals. The results of twenty five granulometric and chemical analyses of additional sand samples confirmed the results of the earlier investigation (report dated 15th December 1987). In particular, the arithmetic means of SiO_2, TiO_2 and Fe_2O_3 of the second series correspond well with those of the first series. The comparatively high TiO_2 and Cr content points to a relatively high heavy minerals contents of the silica sands. The granulometric analysis of the second series has revealed that 93.0wt.-% of the silica sand is in the 0.112 to 0.630-mm fraction. A great advantage is the fact that there is a distinct concentration in the 0.112 to 0.200-mm and 0.200 to 0.355-mm fraction. Of particular disadvantage is the considerable variation of the grain size distribution from sample to sample. From the results obtained – first and second assessments; further analysis would show similar results. After sufficient beneficiation the Tutong silica sands can meet the requirements for high-grade domestic and decorative glassware and probably for fine optical products[22].

1.6 Specifications and Reserves

Most glass manufacturers set their own specification for chemical analysis and granulometry of silica (Si). According to BS2970, Tutong silica sands are only conditionally suited for producing grade C glass (general colorless glass including container glass) but with suitable refinery methods it is possible to produce high quality silica sands. The grain size distribution of approximately 90% of Tutong silica sands are within the desired grain size range. There is a distinct concentration in the 0.112 to 0.200-mm and 0.200 to 0.355-mm range (good). Occasionally there are large amount of grains › 0.63 mm fraction (which is undesirable). A consistently uniform grain size composition can be obtained by suitable methods. Average SiO_2 content is approximately 98.85wt.-% cannot be classified as a high quality glass sand but with modern approaches, high technology refining, it is possible to increase SiO_2 content to › 99wt.-% and to reduce detrimental oxide contents. The silicon dioxide is used to produce the elemental silicon and the process involves a high temperature reduction with the elemental carbon in an electric arc furnace[23]. The degree of roundness of grains varies from moderate to poor with good fusibility and melting properties. Heavy minerals are concentrated near the surface of the silica sand viz. chromites, which causes a distinct greenish tint in the glass. For a high quality glass heavy mineral content can be drastically reduced by flotation. Tutong silica sands can meet the requirements of British Standard BS 2975:1953 for a high grade domestic and decorative glassware (grade B), and possibility grade A for fine optical products but they generally meet the requirements of grade C, for the general colorless glassware. The total reserves for Brunei's silica sand in the area South-west of Tutong alone starting from Serambangun, Tanjong Maya, Bukit Udal, Bukit Beruang and Telamba are estimated › twenty million tons. This estimated reserve is sufficient for many hundreds of years of production from a glass plant with an annual estimated capacity of 34,000 tons but a detailed reserves calculation is necessary to precede any future quarrying. The total area of Brunei lands covered by the silica sands is approximately 13.1774 Km^2 **(Table 1.1)**. This land mainly belongs to the government, more than 90%, other areas are privately owned land for housing settlements and other human activities.

Area	**App.(Hectare)**	**App.(Acre)**	**App.(Km^2)**
Brunei Muara District (Meragang)	70.1909	173.4393	0.7019
Tutong District (Mukim Pekan Tutong, Tanjong Maya and Telisai)	804.9188	1988.9271	8.0488
Belait District (Mukim Sungai Liang and Bukit Sawat)	442.6874	1093.8656	4.4267
Total	**1317.7971**	**3256.232**	**13.1774**

Table 1.1: Distribution of land covered with Silica Sands (**Source:** Land Survey Department, Ministry of Development, Brunei Darussalam, May 20012).

1.7 Environment and Ecological Controls

All developments intrinsically involve a trade-off between potentially conflicting goals, such as between economic growth and conservation. The challenge is to optimize these trade-offs between and across the three systems basic to development, which are: ecological system, the economic system and the social system (Heidenheimer, 1983) (Barbier, 1987; Holmberg et. al.,1991). The environmental impact assessment (EIA) may be defined as a formal process used to predict the environmental consequences of any development project and is one of the several tools that can be used to improve the way in which trade-offs are made. It ensures that the potential problems that are foreseen are addressed at an early stage in the project's planning and design, and helps to inform relevant decision making bodies and enables decisions to be made so a project can be taken with full knowledge of the likely environmental consequences. It is concerned with identifying, predicting and evaluating the foreseeable impacts, both beneficial and adverse, of public and private (development) activities, alternatives and mitigating measures, and aims to eliminate or minimize negative environmental impacts and optimize positive impacts[24]. It is a process that is used to predict the environmental consequences of a proposed development project. Its aim is to ensure that potential problems are foreseen and addressed at an early stage in the project's planning and design. It is meant to be a management tool for project initiators as well as the relevant authorities to come to a sensible and practical decision on the proposed project. Information gathered from the EIA study can be used to design a project that is economically and most importantly environmentally sustainable. The Environmental Impact Assessment for Brunei Darussalam includes:

i. Identification of sources of pollutants emitted as a result of the proposed development project, which need to include the source of emission, amount of discharge (of effluent) and amount of waste produced
ii. Quantification of the impacts of the emissions and provide a detailed evaluation
iii. Propose appropriate mitigation measures to be undertaken with regard to safe design and operation of the proposed development project to either reduce emissions so that they are acceptable according to Brunei Darussalam standards or are deemed acceptable to the general public and the environment

The Environmental Impact Assessment process covers various topics in a systematic way; including

i. Collection of information about an area and its characteristics
ii. Predictions of the effects of a development on the area including effects on people living in or using the area
iii. Vital information that can be used to make an informed decision regarding whether the development should be permitted

iv. Introduction of changes into the design process to ameliorate any adverse effects of the project where necessary
v. Consultation between the developer, stakeholders and decision-makers assisting in resolving any conflicts between the project proponent and the public

The Environmental Impact Guidelines for Brunei Darussalam are guidelines for various forms of developments that are proposed to be carried out in Brunei Darussalam, and has been designed to complement the Pollution Control Guidelines for Industrial Development in Brunei Darussalam. Prediction attempts to determine the cause and effect of the impacts, although often these are not well understood. Prediction relies on data and analysis from a variety of sources; i.e. physical, biological and sociological. The quality and availability of data often imposes an important constraint to accuracy and reliability predictions. The EIA process attempts to determine the significance of impacts, a task that is often subjective and value-laden. For example, an impact at a national level might be regarded as insignificant but could be highly significant at a local level[25].

The various quantitative approaches to assess the significance of impacts have been developed to assist in quantifying and rating relative effects but these tend to rely on the availability of good scientific data. More tangible considerations include:

i. Existing legislation, regulations or accepted standards
ii. Protected status of particular areas or ecosystems, landscapes and species
iii. Government policy objectives
iv. Acceptability to potentially affected people and the general public

Methods used for the prediction of impacts used in various forms of developments **(Table 1.2)**

Impacts	**Method/Model**
Air	Air dispersal/emissions models
Noise	Noise impacts from activities
Soil erosion	Models indicating soil loss
Changes to hydrology/water quality	BOD estimates in rivers/other parameters

Ecology	Suitable ecological models which can be used for comparative assessments
Land use	Evaluation against present structure/existing plans
Visual	Critical Assessment
Socio-economic	Cost-benefit Analysis

(**Source:** Department of Environment, Parks and Recreation, Ministry of Development, Brunei Darussalam, 2012)

Presently, there are no proper facilities for the disposal of most toxic waste in Brunei Darussalam. Brunei Shell has its own procedure for management of toxic chemicals and hazardous waste. A proposal has been made for the provision of a new and improved oil treatment/recycling centre. The estimated pollution load from industrial waste is low compared to the domestic waste. All pollution-risk industries are required to adopt the clean technology available. Consistent with the stated policies and legislation of the Government, Brunei shell has formulated its own Environmental Management Plan. The plan includes practices procedures and standards pertaining to air quality, water quality, and waste management. It also includes monitoring programmes, EIA procedures and environmental audits[26].

There is no single agency in Brunei Darussalam that has the sole responsibility for environmental matters, including the enforcement of environment related laws. Such responsibilities are fragmented among different ministries, departments and units. As a general rule, environmental policies are usually promulgated as administrative orders. These along with many of the existing laws tend to be brief and general. Many of the environmental regulations appear as incidental provisions in the sectoral legislation governing other areas. These regulations and acts are inadequate in terms of their scope and enforcement, nor are they sufficient in terms of environmental management. No single coherent Act exists to harmonize the environmental protection efforts. As such, the provisions governing pollution and the environment are incomplete and piecemeal and laws governing some types of pollution are non-existent. Many of the existing provisions also grant wide powers and authority to ministries and departments, leaving many issues to be determined at the discretion of unqualified administrators. Brunei Darussalam does not have specific laws requiring environmental impact assessment (EIAs). However, environmental considerations are currently incorporated into development decision-making through land use planning and zoning requirements. New industries must submit plans indicating measures to be taken to alleviate environmental impacts. In addition, most of the existing environmental laws pre-date the current interest in environmental protection and have not yet been amended to incorporate modern environmental principles[27].

1.8 Silica Sand Industry

Industrial silica sand consists of small-sized, circular, uniform quartz grains that provide strength and crush resistant qualities. Density and toughness of granular sand provides various features such as porosity, durability and gravity. Low coefficient of thermal expansion of industrial silica sand makes it an ideal solution for usage in extreme temperature applications such as glass manufacturing, foundries, shale gas hydraulic fracturing and abrasives. Demand for industrial silica sand in hydraulic fracturing has increased exponentially since the shale gas revolution. Ferrosilicon accounts for about four-fifths of world silicon production (gross-weight basis). The leading countries in descending order of production, for ferrosilicon production are China, Russia, India, the United States and Norway, and for silicon metal production, the leading countries are China, Norway, Brazil and Russia. China was by far the leading producer of both ferrosilicon (3,900,000 tons) and silicon metal (780,000 tons) in 2010. Ferrosilicon, an iron-silicon alloy that contains varying ratios of elemental silicon and iron, accounts for about 80% of the world's production of elemental silicon, with China, the leading supplier of elemental silicon, providing 4.6 million tonnes (or 2/3 of the world output) of silicon, most of which is in the form of ferrosilicon. It is followed by Russia (610,000 t), Norway (330,000 t), Brazil (240,000 t) and the United States (170,000 t). Ferrosilicon is primarily used by the steel industry. The estimated value of silicon alloys produced in the United States in 2010 was US$770 million. The main consumers of silicon metal were producers of aluminum and aluminum alloys and the chemical industries. The semiconductor and solar industries, which manufacture chips for computers and photovoltaic cells from high-purity silicon, respectively, accounted for only a small percentage of silicon demand. The important sources of ferrosilicon between 2006 until 2009 were China 46%; Russia 24%; Venezuela 14%; Canada 9% and other producers 7%. While the silicon metal suppliers were: Brazil 44%; South Africa 28%; Canada 17%; Australia 10% and other producers 1%. Overall supply breaks down as China 26%; Brazil 21%; Norway 13%; Russia 13% and other producers 27%. The annual average US spot market prices significantly rose in 2010 from those of 2009, as silicon material suppliers increased output to meet consumers' needs. Domestic secondary aluminum production; the primary materials source for aluminum-silicon alloys was projected to decrease by 6% in 2010 compared with that in 2009 for the US.

However, its domestic chemical production was projected to increase by 3% in 2010. The world production of silicon materials increased in 2010 compared with that in 2009, mainly as a result of restarting ferrosilicon smelters that had been shut down at the end of 2008 and in 2009[28]. The elemental silicon not alloyed with significant quantities of other elements and usually > 95% is often referred to loosely as silicon metal. It makes up about 20% of the world total elemental silicon production, with less than 1 to 2% of total elemental silicon (5 - 10% of the metallurgical grade silicon) ever purified to higher grades for use in electronics. The metallurgical grade silicon is commercially prepared by the reaction of high-purity silica with wood, charcoal and coal in an electric arc furnace using carbon electrodes. The metallurgical grade silicon has its primary use in the aluminum casting industry to make aluminum-silicon alloy parts. The remainder (about 45%) is used by the chemical industry where it is primarily employed to make fumed silica. As of September 2008, metallurgical grade silicon costs about US$1.45 per pound (US$3.20/kg), up from US$0.77 per pound (US$1.70/kg) in 2005. The solar grade silicon cannot be used for semiconductors, where purity must be extreme to properly control the process. Bulk silicon wafers used at the beginning of the integrated circuit fabrication process must first be refined to nine-nines purity (99.9999999%), a process which requires repeated applications of refining technology[29].

1.9 Thesis Structure

Chapter: 1 constitutes general overview on the literature review, introduction to Brunei Darussalam, issues of economic growth and gives a statement of the problems; explains the outline of Brunei's economic backbone and the existence of silica sand that can be future hi-tech industrial sector. This chapter also explains research aims and objectives.

Chapter: 2 includes background studies and explanation of industry-based technology, its contribution and definitions. Components of technology, phases of technology transfer, transfer of technology, Hi-tech, industrial robots and automation, innovation and industrialization factors.

Chapter: 3 contain explanation of the research methodology. This chapter explains the research process and addresses the issues of research philosophy. SWOT-analysis and case study, research scope and limitations.

Chapter: 4 contains the presentation of the SWOT-analysis, feasibility of different hi-tech industries, comparative studies, discussion and study outcomes.

Chapter: 5 consists of case studies of successful technology transfer in different countries, lessons learnt, findings and results. This chapter plays a critical role in the achievement of research aims and objectives.

Chapter: 6 concludes the work and summarizes the level of achievement of research aims and objectives. The chapter comprises general conclusion and recommendation to improve existing industrial policies.

1.10 Conclusion

In conclusion, Brunei's domestic market needs to be assessed and the rate of development of targeted industrial sectors has to be evaluated to explore ways that encourage foreign direct investment and promote technological transfer. Thus, technology transfer is an essential part in this research. The key questions framing this study are the significant importance of technology transfer and the need to shift from hydrocarbon-based industry to hi-tech industry, its theoretical ideas and technological developments. Abundant deposits of silica sand available in Brunei Darussalam suggest that it has potential for the development as a hub for solar panel glass manufacturing and other high valued down-stream industries. Overall, this research aims to study factors for the successful transfer of technology-based industries, identify key issues on technology transfers that significantly affect the rate of technological integration and evaluate the concept of technology transfers and its significant contributions to the sustainable economic development of a small state economy.

CHAPTER 2:

INTRODUCTION

2.1 Summary

Technology-Based Industries account for the largest share of employment, business activity and labor income. These contribute to multi-lateral development of a nation's economy through innovation, new technologies and use of new knowledge. In the new economy, technology is the key to sustainable economic prosperity of a nation. In the literature technology transfer is believed to be one of the major vectors for prosperity in developing economies. The experiences of some successful countries in rapid economic and industrial development, in particular, some ASEAN Newly Industrialized Countries indicate that the acquisition of a significant amount of foreign technology has played a crucial role. These experiences could provide valuable lessons for Brunei Darussalam who wish to diversify its economy from heavily reliant on hydrocarbon into technology driven industries to achieve rapid industrialization and technological development.

2.2 Background

Technology-based industries continue to be at the forefront of a nation's sustainable economic development. They account for the largest share of employment, business activity and labor income in most primary sectors. Technology-Based Industries contribute to multi-lateral development to a nation's economy through innovation, new technologies and use of new knowledge. Advanced economies continue to have evolution in their economic structure. Methods by which goods and services are produced are continually evolving and there are rapid changes in the use of labor and capital in the production process. Factors considered in alternative definitions of technology-based industries include; the nature of products or services they produce, characteristics of the production processes, the structure of the labor force, the ratio of the research and development spending as a fraction of sale revenues and the length of product life-cycles. Industrial technology is the use of engineering and manufacturing technology to make production faster, simpler and more efficient. Most modern industrial technology adopts computerized-programming of production machines that eliminates errors and time lost in the assembly or manufacturing lines that consequently results in highly profitable production. This industrial technology field employs creative and technically proficient individuals who can help a company achieve efficient and profitable productivity[30]. In the new economy, technology is the key to sustainable economic prosperity of a nation. Technology transfer is extensively believed to be one of the major debates in the literature in developing economics. The experiences of some successful countries in rapid economic and industrial development, in particular, some ASEAN Newly Industrialized Countries (NICs) show that the acquisition of a significant amount of foreign technology has played a crucial role. This crucial role includes promoting their managerial and technical expertise as well as increasing their productivity level through the adoption of a set of appropriate policies and strategies. It also simultaneously promotes technological innovation and the state of the art of know-how on advanced technological applications. These experiences could have valuable lessons for Brunei Darussalam who wishes to diversify its economic background from heavily reliant on hydrocarbon into technology driven industries to achieve rapid industrialization and technological development. Although many Less Developed Countries (LDCs) have realized the significant importance of technological transformation for their rapid economic and industrial development, they have not designed effective and efficient policies for the transfer of appropriate and high-level technologies. Technology transfer is regarded as the key element for industrialization and economic diversity. Technology is widely accepted as essential for improving the economy of a nation, in particular, in the developing countries where industrial growth has occupied a very important role (Guan, Mok, Yam & Pun 2006). Evidence from many countries has shown that a country's international competitiveness and capacity to grow in the long term is dependent on its ability to master new technology and to manage, and generate technological change. Technology can contribute to the development of society and the economy of a nation through the invention, diffusion, transfer and application of new knowledge. It is an essential prime mover for economic growth. There has been rapid growth in technology-based industries compared to overall economic activity in the USA. Employment has expanded from 96,000 private sector jobs in 1974 to 372,110 private sector jobs in 2009, an increase of 296%. This compares to state wide increase in state employment of 210% over the same time period. In 2009 there were 9,436 public sector and Federal research related jobs in Washington State, bringing total technology-based employment to 381,546. Total technology based employment has grown from 6.7% to 13.2% of total state covered employment over the 1974-2009 time period, indicating that technology-based industries have made a growing contribution to the economic base of the state[31].

The Research and Technical Development (RTD) activity performs a specific group of activities within a business with two primary models i.e. to develop new products and to discover and create new knowledge about scientific and technological topics for the purpose of uncovering and enabling development of valuable new products, processes and services. Under both models, Research and Development (R & D) differs from the vast majority of a firm's activities, which are intended to yield nearly immediate profit or immediate improvements in operations and involve little uncertainty as to the return on investment (ROI). The first model of Research and Development (R & D) is generally staffed by engineers while the second model may be staffed with industrial scientists. Technology development is the basic means through which firms, industries and countries can foster their competitive capabilities and increase their competitive advantage. A major subject of study is technological development in industry[32]. This has been defined as

i. the introduction of new tools and techniques for performing given tasks in production, distribution data processing (etc.)

ii. the mechanization of the production process, or the achievement of a state of greater autonomy of technical production systems from human control, responsibility or intervention

iii. changes in the nature and level of integration of technical production systems or enhanced interdependence

iv. the development, utilization and application of new scientific ideas, concepts and information in production and other processes

v. enhancement of technical performance capabilities, or increase in the efficiency of tools, equipment and techniques in performing given tasks

Technology is man-made and comprises of two main components; namely "Hardware" which is the collection of physical elements that constitutes a computer system and "Software" which is the programs and other operating information used by a computer. Technology provides a powerful tool for socioeconomic development of a nation. The modern development would have been essentially inconceivable without the technology support. Technology is bought and sold in the world market as a commodity in the form of capital goods and sometimes intermediary goods; human labor usually skilled and sometimes highly skilled and specialized manpower; and information, whether of a technical or of a commercial nature. Technology is an activity that forms or changes culture. It is the application of math, science and the arts for the benefit of life as it is known. Technology is viewed as an important catalyst of national economic growth (Millman 2001). Technology strengthens the national development and international competitiveness of countries. In the emerging global economy of the 21st century, technology is a key to sustainable economic prosperity. Under rapidly changing global economy, technology development is closely associated with the competitive advantage of each nation (Sung 2009). Technology can result from the application of science to add value, simplification, diversification and productivity to a management process or product. However, technology's value wanes unless it can be transferred to a user who can apply the technology to create a tangible benefit. Arising from this assertion, the vitality of public good science funding is critically dependent on technology transfer. Technology significantly affects human abilities to control and adapt to natural environments. It helps to develop advanced economies and has allowed the rise of a leisure class. Never the less many technological processes produce unwanted by-products and deplete natural resources to the detriment of Earth's environment. Various implementations of technology influence the values of a society and new technology often raises new ethical questions. Examples include the rise of the notion of efficiency in terms of human productivity, a term originally applied only to machines and the challenge of traditional norms. The literature on technology management has numerous definitions of technology. In this study, it is considered that technology consists of four basic components, namely;

i. Technoware (Facilities - Object embodied technology)
ii. Humanware (Abilities - Person embodied technology)
iii. Inforware (Facts - Document embodied technology)
iv. Orgaware (Framework - Institution embodied technology)

All the four components of technology are required simultaneously in any transformation operation that involves the production of goods through the conversion of material inputs into outputs and they are complementary to each another. Ordinarily technology is considered as something physical. It is rarely understood as a transformer of resources; not only physical tools and facilities (hardware). In addition to the hardware, transformation of resources for economic growth requires human skills, accumulated knowledge and institutional arrangements.

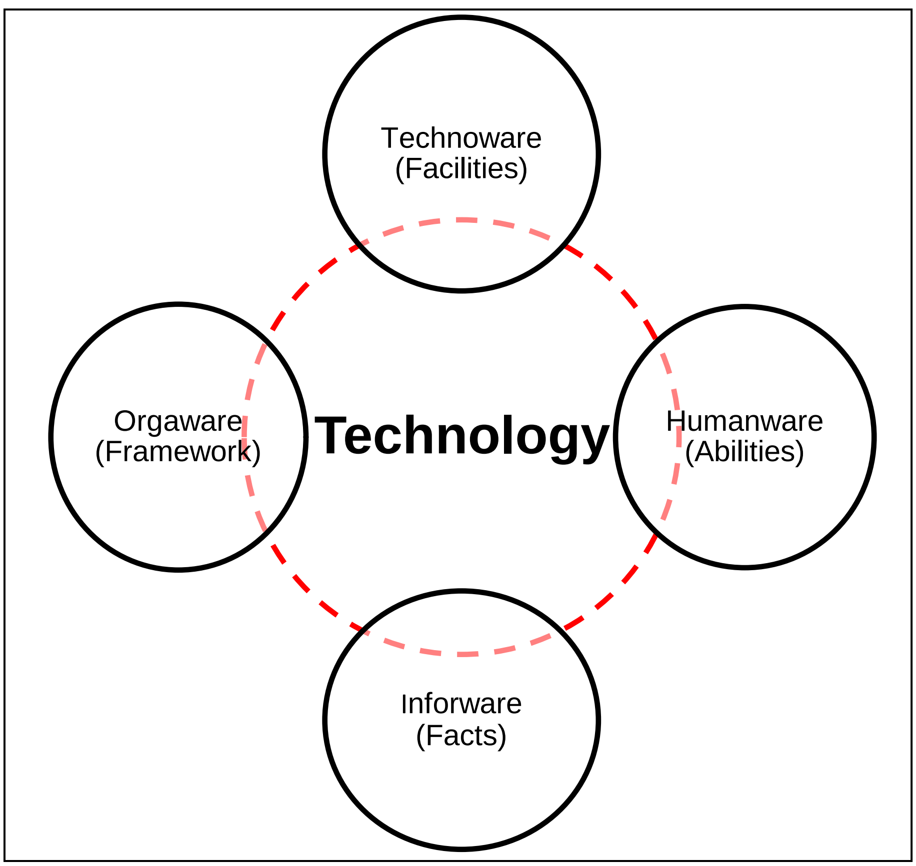

Figure 2.1: Basic components of Technology

The international transfer of know-how, knowledge and technological expertise is growing and they are increasingly important in the world economy (Archibugi and Lundvall 2001, Archibugi and Pietrobelli 2003). Technology transfer (TT) suggests the movement of technology from one entity to another, for example, from one organization to another, from a university to an organization, or from one country to another. The complexity of the technology transfer process depends on the type of technology, the owner's capability of transferring, the acquirer's capability of assimilating and the complex interaction between the two parties (Goc 2002, Lee, Wang and Lin 2010). The concepts of technology transfer have been defined in many different ways. However, there is usually an agreement that technology transfer requires mainly a human effort. The transfer of technology often requires collaborative activity between two or more individuals or functional units who are separated by structural, cultural and organizational boundaries. Technology transfer is an interactive process among entities over an extended period of time. Technology transfer is also defined as being product-embodied, process-embodied or personnel-embodied. It can be a lengthy, complex and dynamic process and its success is influenced by various factors originating from many different sources (Kumar, Kumar and Persaud 1999, Walter 2000). With special reference to developing countries, Hoffman and Girvan (1990) suggested that Technology transfer needs to be perceived in terms of achieving three core objectives:

i. the introduction of new techniques by means of investment in new plants
ii. the improvement of existing techniques and
iii. the generation of new knowledge

It is emphasized that industrialization is the main path for economic growth and development by many nations. However, its success is dependent on the availability of the required technology and the capability to use technology effectively. For achieving rapid technological advancement, many countries emphasize the "Transfer of Technology" as a rational way. Hence, in the developed and the developing countries, technology transfer has become a subject of considerable research activity. Technology transfer is a process in which a technology generated in one place is adapted and utilized or diffused in other places. Technology is carried across the border of two entities that can be nations, industries, firms or even individuals and it can be interpreted as an active process. There must be a transferor and a transferee for technology transfer to occur. The transferor has higher technological level than the transferee. A technological level is defined as the capability of the technological system that consists of technoware, humanware, inforware and orgaware. The technological gap between the transferor and transferee offers a potential for technology flow. Unless the technology transferred to a country from outside is efficiently and effectively assimilated within the country, it would not contribute to national development. The success or effectiveness of transfer depends to a large extent on the transferring capabilities of the transferor and the selection, adaptation and assimilation capabilities of the recipient of the technology. The assimilation capabilities of the countries have direct relationship to their technological levels. An effective technology transfer program would help the transferee in terms of reduction of time and cost of transfer and increase in the rate of absorption and diffusion of technology. Therefore, effective management and transfer of technologies are believed to be increasingly critical for individuals, organizations and nations in the globalized knowledge society of the 21st century (Sung 2009). Technology transfer appears to be a simple communication process. However, in-depth analysis reveals a predictable learning pattern whereby comprehension of the technology is first achieved followed by the interpretation of how the technology can be implemented to solve a problem and finally, the actual application of the technology to solve a problem. Scientists can influence this pattern, once they obtain the fundamental understanding of the technology transfer process. Technology transfer process is explained with six phases; i.e. technology innovation, technology confirmation, targeting technology consumers, technology marketing, technology application and technology evaluation. Each of the six phases is briefly described with examples of key actions, which demonstrate movement through the process and indicators of transfer, which serve to document progress. Actual key actions and indicators of transfer for the six phases can take a multitude of forms with phases at times overlapping[33].

i. **Phase One: Technology Innovation**

The technology transfer process begins when scientists start communicating ideas of how science can be used to solve problems or improve a situation in a research priority area. This technology innovation phase is represented by the exchange of information which takes place between scientists, colleagues and administrators to advance ideas on the application of science. The next step would be when scientists start discussing their theories with colleagues. This activity may aid scientists in further refinement of the theories and gain suggestions for other possible commercial applications of the technology. In-house seminars and group discussions should be actively organized and supported by all scientists to encourage analysis and support or development of ideas. After refining theories arising from the technology innovation, scientists should submit research proposals communicating the concept to the appropriate funding agency. Such proposals should include plans as to how the research will in fact be applied. Scientists need to be proactive in suggesting end uses for the technology they have created (Risdon, 1992).

ii. **Phase Two: Technology Confirmation**

The technology confirmation phase is represented by scientists first conducting research which provides data in support of the underlying theory about technology and then communicating the results to colleagues, peers and administrators. Indicators documenting progress could be in-house 'Eureka' reports which communicate research success to colleagues and administrators. Bhattacharya, Glazer and Sappington (1992), and Hughes (1992) developed mathematical models balancing the economic benefits versus the deficits of sharing research progress or results with colleagues and competitors. Trotter and Risdon (1990) address the issue of morale benefits, which accrue from colleague interaction establishing the close relationship between morale and productivity. Indicators of transfer in this phase would be in-house reports, presentations and or publications substantiating research success, which aids science liaison within the science community.

iii. Phase Three: Targeting Technology Consumers

During the third phase of the process decisions need to be made concerning who needs and can potentially benefit from the technology. The people involved in the targeting technology phase would be scientists and marketing personnel. These specialists need to be aware of factors such as cost, convenience, etc. which influence users' acceptance of new technology or factors which might serve to prevent the adoption of technology. A multitude of factors for socio-economic considerations for targeting technology change have been encompassed in models by Doherty (1990) and Knudson (1991). For further study, Swanson, Sands and Peterson (1990) conducted an international study analyzing the influence different marketing systems had on technology acceptance by potential users. Indicators of transfer for this phase would be the interactions of science, business and marketing personnel to 'brainstorm' technology acceptance considerations. Grundy and King (1992) advocate the use of a strategic planning process to steer the decision-making operation.

iv. Phase Four: Technology Marketing

The technology marketing phase of the process is concerned with disseminating the technology beyond the research centre. Key actions for science liaison involve the talents of scientists, business leaders and marketing specialists to educate potential consumers to the social, economic and environmental benefits of the new technology. Echeverria and Elliott (1990) suggest frequent interaction between research and marketing personnel; and the benefit of establishing a demographic profile of anticipated consumers before organizing communication channels. Knowing where the potential client usually gains knowledge of specialized products and or services will influence the selection of communication methods. Kaimowitz, Snyder and Engel (1989) counsel using a variety of communication channels to stimulate public awareness and understanding of science or technology.

v. **Phase Five: Technology Application**

The technology application phase concerns the understanding of users or consumers behavior and establishing predictable steps to monitor the commercial application of technology. The talents and skills of social and financial consultants and marketing personnel are required to identify consumers' behavior and application patterns. Social, economic and environmental factors, which influence the rate of adoption of new technology, are discussed in-depth by Arnon (1989). Chari and Hopenhayn (1991) have developed a mathematical model, which weights social and economic factors and their influence on the diffusion of technology innovations. The ratio of the number of consumers applying the technology to the number of potential consumers needs to be carefully monitored to establish the market share reached.

vi. **Phase Six: Technology Evaluation**

The sixth phase of the technology transfer process documents the success or lack of success of the technology to be adopted. Key actions for the technology evaluation phase are to establish assessment criteria for authenticating socio-economic and environmental benefits or harm. Guidelines for evaluating different types of technology innovations are proposed by Cummings (1990). Assessing technology transfer effectiveness generally requires specific criteria, which can provide a basis for measuring the extent to which key actions have been attained. The method of defining specific criteria for indicators of transfer is essentially moving from broad to specific actions. The stronger the indicator of transfer, the more useful the indicator is for making decisions on present and future public good science funding. The technology transfer process ends when the scientists report the evaluation findings back to the funding agency.

Technology transfer usually takes place at the firm level, between a firm in the supplier country and a firm in the recipient country. However, the government policies on technology transfer are generally formulated at the industrial level. The science and technology agreements are signed between governments with the objective of facilitating the technology transfer between an industry in the supplier country and the corresponding industry in the recipient country. The technology transfer process describes the linkages, which integrates the adoption of new science knowledge and the functional interrelations of the different specialists within the process. The flow-system model has been presented to encourage scientists to become more proactive in monitoring the understanding, interpretation and application of the technology they have created. The concept of technology transfer inhabits the scientific and technological creativity of the society.

Technological innovation is a key element of industrialization and catch-up in developing countries. It is the process through which new or improved technologies are developed and brought into widespread use. Since innovation is costly, risky and path-dependent, groundbreaking innovation is highly concentrated in a few rich countries and amongst a small number of firms. Foreign sources of technology account for a large part of productivity growth in most countries. If foreign technologies are easy to diffuse and adopt, a technologically backward country can catch up rapidly through the acquisition and more rapid deployment of the most advanced technologies. Therefore, the development process in low income countries can be supported by tapping into existing knowledge and know-how. The transfer, adoption and adaptation of knowledge to low income countries hence constitute an important issue for economic growth and global development. Innovation is an outcome of a collision between technological opportunities and user needs. The focus is upon the interaction between producers and users of innovation. One outcome of the analysis is a more realistic understanding of markets and vertical integration.

The technology innovations and their diffusion have been studied by many researchers (Blackman 1971 & 1974; Fisher and Pry 1971; Gold, Peirce and Rosegger 1975; Hough 1975; Lakhani 1975; Mahajan and Schoeman 1979; Nielsen 1974; Sharif and Kabir 1976). Technological innovation performs a function in a better and efficient way and it contributes to technological substitution over time. Technology substitution is the process of substitution of one technology for another. Technology substitution models have been developed by Mansfield (1961), Fisher-Pry (1971), Blackman (1972), Floyd (1968), Ayres-Noble-Overly (1967), Sharif-Kabir (1976). Number of studies (Nesbath and Ray 1974; Nielsen 1974; Swan 1973; Gold 1981; Metcalfe 1970; Ray 1969; Romeo 1975; Sharif and Ramanathan 1982; Buzzelli 1982; Clark, Freeman and Soete 1981; Vickery 1981; Madeuf 1982) had focused the international diffusion of technological innovations. Many researchers (Balasubramanium 1973; Baster 1972; Gruber and Marquis 1969; Hall and Johnson 1970; Hawthorne 1971; Joshi 1977; Spencer and Woroniak 1967; Teece 1981; Ramanathan 1994; Schwartz 1982; Simon 1991; Davidson 1980; Cusumano and Elenkov 1994; Madeuf 1984; Jequier 1976; Mytelka 1985; Todaro 1985; Hoelscher 1975; Reddy and Zhao 1990; Mock 1974; Patel 1972; Streeten 1972; Barranson and Roark 1995; Desai 1994; Katz 1985; Seaton and Cordey-Hayes 1993) studied on the subject of technology transfer in a descriptive nature. A number of qualitative analysis and case studies of technology transfer between countries have been done (Barranson 1969 & 1981; Barrokman 1983; Bucy 1981; Hayden 1984). The quantitative or mathematical modelling has not been significantly utilized in analyzing the technology transfer process even though many studies on technology transfer have been done using qualitative methods. Some of the well-known quantitative studies on technology transfer were done by Haq (1979), Suckchareonpong (1979), Baruch Raz, Gerald Steinberg and Andrew Ruina (1983), Baruch Raz and Isak Assa (1988), Liu (1993), Bhargava (1995), Jayaraman, Truong and Agrawal (1998). It is possible that more contribution to the knowledge relating to technology transfer can be made by studying the process of technology transfer using quantitative methods. If we can quantify the technological levels of the transferor and transferee, then it would be possible to model the technology transfer process quantitatively. A methodology to evaluate the technology transfer potentials incorporating the time, technological levels and potential technology distance between the transferor and transferee will help in understanding the complex process of technology transfer. The quantitative models could give a different approach and better understanding of the technology transfer process. In the absence of infrastructural investment in education, training, research and development (R & D) as well as other scientific and technical activities very little can be accomplished by way of assimilation of imported technology. Most ASEAN countries are by far the most proactive in promoting this infrastructural investment. The variety of strategies in the ASEAN countries is designed in different ways steadily to upgrade domestic technological capability. Many European companies traditionally came to South-East Asia to take advantage of low-cost manufacturing for export, but more recently, they have come to enter the local domestic markets, establish Research & Development, engage in cooperative development, avail of a skilled work force, establish suppliers and develop long-term partnerships in key markets across the region. In order to achieve this, they are often willing to transfer some of their technologies and designs to local subsidiaries of European firms, joint-venture partners, or local manufacturing and service companies.

The technological characteristics of small scale industry in developing countries could be measured in terms of six specific variables; i.e. economies of scale, the technological base, the technological disparity, the infrastructural base, learning, industry differentials, labor intensity and the linkage pattern. The list is by no means exhaustive but it provides as complete a view as can be, of the different factors at play in the determination of the technological characteristics of the sector. Each of those variables is closely examined;

i. Economies of Scale

Small industrial units are, by assumption, limited scale manufacturing operations that do only selectively, demonstrate the typical impact of scale on productivity and output. They emerge and persist in industries where scale economies are either relatively unimportant or are associated with limited levels of employment and investment. They also decline whenever scale economies become significant. Breaking the size barrier is, in fact, a measure of success of the small industry entrepreneur. The experience of Korea and Taiwan (Ho, 1980) is of assistance in throwing some light on what could be considered, for various industries, the minimum efficient plant size and in what industries could small scale manufacturing units be considered efficient.

Korea and Taiwan have experienced a shift from small low technology content industries in the late fifties and early sixties to large high technology content industries in the seventies and eighties. Both countries had a strong small industry sector in the sixties that declined - in terms of total employment - gradually but measurably, over the last two decades. The share of Korean small enterprises (between 5 to 49 employees) declined from 54% in 1958 to 17% in 1975. The identical share of Taiwan small industrial units demonstrated a parallel decline from 45% 1954 to 26% in 1961 (Ibid).

A walking tractor hauling poles on a trailer

In Korea, in particular, an estimation of efficient plant size according to the "survivor technique" (calculating for two points in time the share of an industry's output by size of establishment and consider those sizes that experience increases in their shares as efficient sizes), suggests that the efficient plant size in most industries is above 100 workers (Ibid). It also suggests that the incidence of efficiency in the small industry is most observed in two industrial branches: food and textiles. Summing up, not every small industry is, from a size-technology point of view, appropriate. Certain technologies and industrial branches, lend themselves to small scale application without jeopardizing productivity and efficiency. Those are most common in the wood, furniture, garment, leather and timber industries. The smaller the industry, moreover, the more difficult is the question of size-technology fit. Cottage industries and handicraft should find their justification not because of the level of productivity achieved but because of the level of employment generated. In both Korea and Taiwan three industries accounted for three quarters of the net increase in factory employment in manufacturing, (a) textiles and apparels, (b) products of chemicals, petroleum, coal, rubber and plastic and (c) metal products, machinery and equipment. Within these three groups, strong growth was experienced by such industries as man-made fibers, fabrics, petrochemicals, chemical fertilizers and electrical machinery and apparatus, where the average size of establishment is quite large and where scale economies are known to be important (Ho, 1980). It may be interesting here to refer also to another survey that has been carried out in 1981 of the size of manufacturing plants within thirty three major industries in Britain, Germany and the United States over the period 1970 until 1973 (Paris, 1981) that supports the notion that certain industries are more likely candidates for small scale operations than others. From the thirty three industrial groups surveyed six; leather, clothing, furniture, timber, cement products and beverages, had a median plant size of 100 employees or less in Germany. Britain demonstrated a larger plant size for clothing, furniture and cement. The United States, on the other hand, demonstrated an even larger plant size than those of Germany and Britain. Other industries demonstrated a larger size of employment, across the board with little significant country differentials. **Table 2.1:** Median plant size in selected industrial groups 1970 until 1973 (number of workers).

	Britain	Germany	USA	Germany/Britain
Leather etc	90	70	160	.81
Clothing	120	100	180	.78
Furniture	130	70	200	.56
Cement etc	140	70	80	.45
Timber	60	20	110	.27

Table 2.1: Plant size for different Industries

There's need to increase efficiency and reduce drudgery

ii. Technological Base

Small industries are dependent for their equipment and process technology on a limited number of resources that start with (a) the entrepreneurs' own technical expertise probably gained during earlier stages of paid employment (Schmitz, 1982); (b) large firms that provide the technology as a component within a sub-contracting arrangement (Ibid); (c) government institutions desirous to support a measure of indigenous technology, and although the level of technology associated with any small industry initiative is a function of all three variables, there is sufficient evidence to suggest that the first is the prime source of technology in small industry in a significant number of developing countries.

A case study from Brazil (Schmitz, 1980) indicates that a thorough knowledge of the production process tends to be the small producers' strong point. "The most important source of skill and know how found was previous wage employment. The training and experience gained in this way varied with the job previously held, but generally it provided a sufficient basis to pick up the missing technical aspects through a process of learning by doing, which was an integral part of the small producers' struggle for survival or expansion". Similar conclusions were reached in Eastern Africa (King, 1974, 1975 and 1979). This fairly narrow base of technological input does result in a strong measure of technological "retardness" that expresses itself in, among other things, a comparatively low level of labor productivity in the respective plant or plants. "Many small scale operators are engaged in a process of production and technological development but their ability to develop cumulatively over extended periods is limited" (Bienefeld, 1975).

iii. Technological Disparity

The generic term small-scale industry conceals, in fact, three levels of technological sophistication each related to a specific type of activity: craft production, cottage industries and small manufacturing. Each of those three is, in fact, a distinct mode of production with a different scale and level of technology parameters. The simplest and least problematic level of technology is that of crafts. Carpentry, furniture etc. demand relatively limited technological input. Cottage industry demands a relatively higher level while small-scale industry could demand again comparatively: the highest level of technological input in the sector. The five levels of technological input identified in the case of a sample of seventy small scale carpenters in Dakar (Van Dijk, 1982) could provide an illustration (see **Table 2.2**).

Technology	**Share**	
	Number	%
Simple tools, no machines.	57	81
One machine, relatively simple (e.g. boring machine)	5	8
One combination machine	3	4
Several machines including a combination machine	5	7
An appropriate technology (e.g. circular saw)	0	0
Total	70	100

Table 2.2: Technology Level among a sample of carpenters in Dakar, 1977. (**Source:** Van Dijk, 1982)

These conclusions are also supported by the Food and Agriculture Organization (FAO) study exploring the level of mechanization of a number of small forest based industries in Jamaica, Thailand, Honduras, Egypt, Sierra Leone and Bangladesh (FAO, 1985). The study revealed that a large number of small (up to 10 workers) forest based industries do not use any machines, whether powered or non-powered (69% in Jamaica and Honduras and 93% and 99% in Egypt and Bangladesh). An examination of the level and availability of equipment and process technology in yet another sample of 465 small enterprises in Senegal (van Dijk, 1982) provides an additional illustration, (see **Table 2.3**). The study distinguishes between two levels of technology, simple and more sophisticated and measures the percentage of each in the respective ample.

Activity	Tool or machine required	% using higher level technology (by No.)
Blacksmiths	Welding equipment	40.3
Brick makers	A block making machine	0
Carpenters	A measuring instrument	21.9
Electrical repair	A measuring instrument	53.3
Furniture making	A sawing machine	88.0
Mechanical repair	A measuring instrument	51.1
Watch repair	A measuring instrument	11.4
Others	A piece of equipment worth more than 10000 F CFA	27.8
Total sample		39.1

Table 2.3: Segmentation of Technology by level among a sample of smaller industrial units in the Senegal, 1977, (**Source:** Van Dijk, 1982)

Factors influencing the choice of a specific level of technology for this group were found to include investment level, scale, knowledge about and accessibility of specific types of technologies, human prejudice against or for a specific technology, cultural factors and the existence of a technology gap i.e. non-conformity of the available technology with the level desired by the entrepreneur or recommended by the feasibility makers.

iv. Infrastructural Base

Experience of a large number of countries in both Africa and Asia has shown that small industry usually needs a strong infrastructural base, although this need may vary according to the size and nature of industry. The smaller the unit and the less formal is its framework, the less the need for this infrastructure. The larger the unit and the more complex the product or the process, the greater the need for this infra structural base. Very small and artisanal establishments provide their own power (mechanical, hand or generator) and can adapt to different types of physical location and shelter (Page and Steel, 1984). The larger small industries are very much dependent on the existence of the facilities usually contained within an industrial estate. These could be technically oriented services as central repair workshops, facilities for the bulk purchase of raw material and warehousing facilities or common facilities such as foundries, electroplating shops, tool and die shops, heat treatment shops, woodworking shops, a quality control laboratory and special machine shops. Although industrial estates are usually the focus of all these facilities, the United Nations Industrial Development Organization (UNIDO) exploration of the relevance and effectiveness of industrial estates for small industry development has revealed, however, that industrial estates had little success in attracting industry to rural areas (UNIDO, 1978).

v. Industry Differentials

The term forest-based industries conceal a number of different industries with different characteristics. They differ in terms of labor input, proximity to the raw material base (the forest), nature of raw materials used and their utilization pattern, sensitivity to scale, resort to technology, marketability of output etc.

Coconut sawmilling in Jamaica

The most important of those, in terms of employment in a number of surveyed countries are those based on wood such as carpentry, furniture, upholstery and wood carving but others as bamboo works, mat making, basket making, hat making, agricultural tools, canning, medical and aromatic herbs etc can also be locally important. Assuming that since all these industries are forest based they are equal in technological and managerial parameters could be dangerous. The very difference between these industries could spell out their susceptibility to stimulation and lead to a direct differentiation in the applied methods and approaches.

vi. Learning

Contemporary and not that distant research have revealed the existence of a measure of correlation between average total or partial cost of production of a product and the cumulative volume of production. Average total cost declines with increase in volume not only as a result of economies of scale but also as a response to four other factors that have proved instrumental in causing a cost decline. Technology is a prime among these factors while dexterity, learning and quality of management follow by not too far a distance. This so called learning or experience impact was traced in large manufacturing operations producing a wide variety of products from integrated circuits to baby food. Although admittedly it has yet to accumulate empirical evidence, that small industries in most developing countries are not susceptible to the learning or experience impact just described. The reasons for that are the following: first is the fact that many small scale industries, also in the forest sector, do not lend themselves to large scale operations. Second is the frequently observed low level of technological input and technological adaptation in many of those industries. Third is the long established high labor intensity and low labor dexterity, in many of those industries. Fourth is the often cited constrained managerial performance of the great majority of these units. And fifth, and last, is the limited scope for learning given the environmental constraints of the industries. As said earlier, precious little empirical evidence is there to support the suggested relationship between learning and the small scale industry sector in developing countries. Suggestive evidence is, however, there.

vii. Labor Intensity

Aggregate data consistently show that increasing size is associated with decreasing numbers of workers relative to capital. This labor intensity of small industry is a favorite argument in favor of the industry and a frequently cited rationale for its stimulation. There are several determinants that could actually lead to this labor intensity. One of these could be the degree of "sophistication" of utilized technology. Differences in labor intensity may simply reflect the impact of differences in the wage/rental ratios facing small and large firms on their choice of both technique and industry. Another determinant may be the degree of informality of the enterprise, with informal sector enterprises more inclined towards substituting capital with labor and employing low-skill, minimum wage-tied labor. The third possible determinant of this labor intensity could be the economies of scale that have been mentioned earlier and the fact that certain industries and industrial branches require considerable capital outlay within a wider span of scale than that reachable by a small industry.

viii. Linkage Pattern

The probability is high that the forward linkage of small-scale forest based industries to large scale industries is lower than their backward linkage. This is due to the non-forest-based raw material purchase by Small-scale Industry (SSI) manufacturers. The extent of the linkage may depend on the level of subcontracting that exists between small and large scale manufacturers although links through the open market could also be important (FAO, 1985).

2.3 Transfer of Technology

Advanced technology may refer to technology that is highly up-to-date at the current time. Technology is the making, modification, usage and knowledge of tools, machines, techniques, crafts, systems, methods of organization; in order to solve a problem, improve a pre-existing solution to a problem, achieve a goal or perform a specific function. It can also refer to the collection of such tools, machinery, modifications, arrangements and procedures. High-tech is technology that is at the cutting edge; the most advanced technology currently available. It is often used in reference to micro-electronics, rather than other technologies. Because the high-tech sector of the economy develops or uses the most advanced technology known, it is often seen as having the most potential for future growth. This perception has led to high investment in high-tech sectors of the economy. High-tech startup enterprises receive a large portion of venture capital but if investment exceeds actual potential, as has happened in the past, then investors can lose all or most of their investment. High-tech is often viewed as high risk but offering the opportunity for high profits. Technology transfer takes place through a number of different channels. Key among these is the foreign direct investment, licensing agreements, joint ventures and research collaboration between private companies and universities or government agencies. The choice of mechanism for individual companies depends largely on business strategy, risk tolerance and available resources. A combination strategy may also be used. For instance, when technology has implications for more than one industry, the originating company or research center may choose to license its innovation for certain uses outside its expertise while directly developing the technology for those areas it is most competent in. The knowledge economy is a term that refers either to an economy of knowledge focused on the production and management of knowledge in the frame of economic constraints or to a knowledge-based economy. In the second meaning, more frequently used, it refers to the use of knowledge technologies such as knowledge engineering and knowledge management to produce economic benefits as well as job creation. The knowledge is the new resource and all companies are Information Companies based on knowledge, and all managers are knowledge managers. Management models are from the industrial age. Many firms have come to understand that they require more than a casual and even unconscious approach to corporate knowledge if they are to succeed in today's and tomorrow's economies. A company truly is a collection of people organized to produce goods, services or some combination of the two. Their ability to produce depends on what they currently know and on the knowledge that has become embedded in the routines and machinery of production. The material assets of a firm are of limited worth unless people know what to do with them. Knowledge Engineering (KE) was defined as an engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise (Edward Feigenbaum and Pamela McCorduck 1983). It is a field within artificial intelligence that develops knowledge-based systems. Such systems are computer programs that contain large amounts of knowledge, rules and reasoning mechanisms to provide solutions to real-world problems. A major form of knowledge-based system is an expert system, one designed to emulate the reasoning processes of an expert practitioner. Knowledge engineers found that acquiring enough high-quality knowledge to build a robust and useful system was a very long and expensive activity. The aim of knowledge acquisition is to develop methods and tools that make the arduous task of capturing and validating an expert's knowledge as efficient and effective as possible. A rapidly growing segment of artificial intelligence that transform the way computers interact with the world. Machines can now mimic highly trained specialists in various fields hence the designation Expert Systems. The rapidly evolving field of artificial intelligence can be classified into several sub-fields but Cognitive Science which is concerned with the science of human intelligence and Knowledge Engineering which is concerned with the application of cognitive science to the construction of machine intelligence. Cognitive Science and Knowledge Engineering complement each other. Both sub-fields rely on the computer as a central vehicle to construct and explore computational models.

Knowledge Management (KM) comprises a range of strategies and practices used in an organization to identify, create, represent, distribute and enable adoption of insights and experiences. Such insights and experiences comprise knowledge, either embodied in individuals or embedded in organizations as processes or practices. Many large companies and non-profit organizations have resources dedicated to internal knowledge management efforts, often as a part of their business strategy, information technology or human resource management departments (Addicott, McGivern & Ferlie 2006). The creation or absorption of new technology has become a vital component for companies to improve or maintain their competitive position in the market place. Companies operating in sectors where competition take place on the basis of price alone such as the extraction of raw materials may rely on new technologies to improve their efficiency in the extraction of raw materials by improving their productive processes or acquiring new machinery and equipment. These companies may also use new technology to better commercialize their products or to improve their management structure, control and communication[34]. Technology transfer is the process by which a technology expertise, know-how or facilities developed by one individual, enterprise or organization is transferred to another individual enterprise or organization. Effective technology transfer results in commercialization of new product or service, or in the improvement of an existing product or process. Small and Medium Enterprises (SMEs) have to decide whether to develop technology in-house or obtain it from others. While investing in technology creation may be cost intensive and risky, as there are many uncertainties linked to the innovation process, it has the advantage of preventing technological dependence on other companies and enables the company to enhance its technological capability and to innovate according to its specific needs. In a large number of cases, firms including Small and Medium Enterprises, especially those with high-tech will rely on both in-house innovation as well as on technology purchased from others as necessary machinery is bought from large firms to make technical improvements to the company's products, processes and/or services[35]. Transferring technology from the developed to the developing countries is an obvious alternative, which should aid the promotion of both economic development and international peace. However, the situation is not as simple as it seems. The main obstacle is the absence of a skilled labor force. Some countries like India and China have this resource but most others have not. In addition, social, cultural and political factors inhibit this transfer. The globalization of economic activity and relations, rapid technological developments, and progressive elimination of trade constraints are some of the most important factors. New technology is frequently a job killer when applied to processes, but is a job creator through product innovations (Schmidt,1983). Innovation in products is seen as a potential source of additional employment (Goddard & Thwaites, 1981). Goddard and Thwaites describe the effect of new technology on process in the following terms; in the case of process innovations the picture is more complex as these could add or subtract from employment levels. For example, if some new process is discovered it could mean that products not previously possible may now be produced with all the attendant employment multiplier effects. Alternatively, new techniques could be developed which reduce the labor input required to produce any given output. The effect is therefore to reduce employment unless the resultant cost savings are passed onto the consumers. In this case if price elasticity of demand is sufficiently elastic, output can be increased. If this same proportionate increase in demand outweighs the productivity increases then employment is encouraged to expand too[36]. Technology transfer system supports high-tech infrastructure and development drive that possesses the potential ability to advance Brunei Darussalam. It is important to examine and evaluate the concept of technology transfer owing to its crucially significant importance for sustainable economic growth. Almost all international business agreements contain provisions on technology transfer and various legislations to facilitate public setting about it. It is necessary to review the concept of technology transfer in order to identify and fully monitor its long-term returns. The development of the hi-tech industrial sector is a key driver of progress while the development of technology transfer is one of the core requirements to ensure continuous development of the domestic industries. The use of high-tech machines reduces operating costs and increases demands. When commodities become cheaper market demands will increase. It takes time for new technologies to be adopted and penetrate markets. It even will consume more time for wide ranging acceptance and the adoption of new technology. It is not easy for users to forget about their current systems simply because a radical new technology is introduced. They will wait until their current equipment becomes obsolete and is no longer economical to use before they invest in emerging technologies. Technology is a key resource of profound importance for corporate profitability and growth. The rise in technology contributes to changes in the demand for labor. Machines have replaced jobs in some sectors but have also generated demand for new services and have resulted to a rise in the number of employment opportunities. It also has enormous significance for the well being of national economies as well as international competitiveness. Effective management of technology links engineering, science and management disciplines to address the issues involved in the planning, development and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organization. Management of technology involves the handling of technical activities in a broad spectrum of functional areas including basic research; applied research; development; design; construction, manufacturing, or operations; testing; maintenance; and technology transfer (Michael K Badawy, 1989). The method of production is of fundamental importance because it governs the nature of inputs, the quantity of inputs in relation to output, the energy requirements, the balance between labor and machinery, the nature of jobs and the potential scale of production. It sets the ground rules for factors of production and, in doing so, controls also the factors of location. Major challenges in manufacturing location have been associated, therefore, with technological evolution[37], i.e. studies conducted to investigate and determine the technical suitability of an equipment, material, product, process or system for the intended purpose.

2.4 High-Technology or Hi-tech

Technological progress is the foundation of efforts to achieve environmental objectives, such as increased resource and energy-efficiency. Without technology and innovation, industrialization cannot occur and without industrialization development will not happen. New technologies underpin and drive "industrialization" through improved processing power in processing information, low cost high bandwidth information logistics, process standardization and higher productivity at all stages. At the level of managerial decision making, industrialization strategies include automation, outsourcing, off-shoring, process reengineering, service redesign, modularization and operations shifting including self-service. For industries there are changes in markets and in the processes of production and delivery. High-technology sector generates profitable economic returns through the most advanced technology known and has always been seen as having potential for future growth. This perception has led to high investment in high-technology sectors of the economy. High-technology startup enterprises receive the bulk of venture capital but if investment exceeds the actual potential then investors can lose all or most of their investment. High-technology is often viewed as high risk but offering the opportunity for high profits. South-East Asia is likely one of the world's fastest evolving technology markets. With growing product and process complexity and rising pressure to create and sustain competitive advantage through rapid, continuous innovation, modern high-tech firms increasingly depend on the efficient management of their research and development (R & D) activities and the knowledge developed through these activities[38]. The local and foreign trading patterns are continuously underpinned by different rates of commercializing new technologies. Consequently, nations, in particular the highly industrialized ones, are nervously extending their participation in the support of science and technology activities. Such measures include research and development (R & D) programs, and multi-disciplinary research centers mainly on engineering or science-based technologies, with an explicit or implicit objective to serve national economic development[39]. The science and technology system has to be understood at three different levels i.e. performing, funding and decision-making of which the later is the most difficult to comprehend as it comprises of both formal and informal structures.

The economic code requires that technology to be capital-intensive, research-intensive, organizational-intensive and labor-extensive.

An analysis of trends in technology intensity show that in the Organization for Economic Co-operation and Development (OECD) area, trade in manufacturing was mostly driven by high-technology industries over the second half of the 1990s and up to the beginning of 2005. In 2001, the strong downturn in information and communication technology (ICT) trade affected trade in most technology industries, but recovery was fairly rapid. From 2005, the value of trade in high-technology manufactures started to slow. In 2007 it stood at broadly the same level as medium-high-technology manufactures. Over the same period, trade in medium-low-technology manufactures rose sharply. The notable increase in the value of trade in medium-low-technology manufactures was due in part to the recent significant increases in commodity prices for oil, petroleum products and basic metals, particularly the metals required for the manufacture of ICT goods. However, in terms of shares, medium-low-technology manufactures ranked third and accounted for 20% of total manufacturing trade in 2007; high-technology manufactures and medium-high-technology manufactures accounted for 23% and 39%, respectively. High-technology manufacturing contributes strongly to the growth of global manufacturing. Between 1997 and 2007, high-technology exports grew substantially faster than medium-high-technology exports in most countries, and notably in the Slovak Republic, Iceland and the Czech Republic, where they represented about 1.5 times the value of medium-high-technology exports. They grew at somewhat under 30% in China and by about 15% in Brazil. Over the period, growth in exports of high-technology goods outstripped growth in total manufacturing except in most OECD accession countries (Chile, Estonia, Israel, Russian Federation and Slovenia), Sweden and Japan. In 2007, only 11 OECD countries and 2 non-members (Israel and Slovenia) show a strong comparative advantage in trade in high-technology manufactures. As in previous years, Switzerland had a trade surplus of over 7%, followed by Ireland with 5%. Trade in high-technology industries represented around 3% of total manufacturing trade in the United States, Mexico and Korea. In Israel and Slovenia the trade surplus was 2% and 1%, respectively. Most countries' comparative advantage in trade in high-technology industries changed little between 1997 and 2007, although there were notable exceptions. It rose by 6 percentage points in Iceland, by 4 percentage points in Switzerland and in South Africa, and by 2 percentage points in Brazil. Over the same period, it dropped by 5 percentage points in Japan and by 3 percentage points in India and in China. Between 1997 and 2007, the picture was somewhat different for trade in medium-high-technology industries. In particular, more countries had a strong comparative advantage in 2007. As in previous years, Japan led with a surplus of 15%, followed by Germany and Ireland with 7% and 5%, respectively. In 2007, Slovenia was the only non-OECD country to have not only a fairly strong comparative advantage of 2% in trade in medium-high technologies but also to benefit from an increase of 4 percentage points in its contribution to the manufacturing trade balance. Over 1997-2007, the contribution of trade in medium-high-technology industries increased by 13 percentage points in Indonesia, 11 percentage points in Turkey and 6 percentage points in China, despite negative contributions to their overall manufacturing trade balance. In 2007, much of the manufacturing trade balance of these countries relied on the positive contribution of low-technology industries[40]. The Brunei Government through the Ministry of Industry and Primary Resources has prepared an Industrial Development Plan (IDP) to cater for niche industries. These include services, export and high technology industries. High technology industries would also include Industrial biotechnology, advanced materials and nanotechnologies.

2.5 Industrial Robots

Innovative technological developments open new doors to completely new applications for industrial robots. These advances continue to contribute to the growth of industries ranging from manufacturing, food and beverage, chemical, rubber and plastics, electrical/electronic and automotive industries to medical, entertainment, agricultural industries and others. From large companies to start-ups, the biggest drivers are leaps in precision sensors, embedded control, intelligent software, advanced end-effectors technology and human-robot interaction. Technological success implies technical solution improvement in the automation domain of technological process and intelligent system application in different branches of industry. Industrial robots as defined by ISO 8373 are automatically controlled, reprogrammable, multipurpose, manipulator programmable in three or more axes which may be either fixed in place or mobile for use in industrial automation applications. The reprogrammable nature of industrial robots allows for change in their motions or functions without any physical alterations. Since these industrial robots are multipurpose, they are capable of adapting to different applications via programming. The use of industrial robots provides the manufacturing sector with the ability to perform complex repetitive tasks in high volume production lines. The growth of the global industrial robotics market is driven by the increase in demand for automation in industrial applications owing to the increase in labor costs and need for rapid and efficient manufacturing processes. With the shift from man-made to machine made products that was ignited in the mid-18th century, a new era of human experience began where increased productivity created a much higher standard of living than had ever been known in the pre-industrial world. In the 21st century, our industries are evolving to be smarter, safer and more efficient. The natural development of robot technology is going from a repetitive performance and function to full mobility and flexibility where robots are fully adaptable to humans and changing environments. The potential is to take away boring work from manual labor and instead allow manual labor to spend time on craftsmanship, customization and adding value, uniqueness and passion to small batch sizes or large product variety. Instead of replacing people, collaborative robots work with humans as intelligent tools; a new breed of robots, evolved from dangerous machines to assistants in a shared workspace. This opens advantageous doors for small and medium sized businesses to gain a unique edge in today's increasingly competitive global market. Adoption of industrial robots for enhancing the productivity of small and medium enterprises (SMEs) provides a significant growth opportunity for the industrial robotics market. New product development and upgrading existing products could stimulate market growth. Their application is motivated for the technical and economical reasons including quality improvement of the completed products (machine processing and other), fall-out decrease (in the assembly process), rate enlargement of the homogeneity-constancy quality (in all process linked to robot application repeatability), security operation rate enlargement (in aggressive, burning, explosive and other areas, with the high rate of robot protection), decrease in the work force required for routine and repeated process, manufacture cost minimization, fulfilling of demands required by competition and more rigorous quality standards. Besides the technical advantages, which are carried out owing to the robot application, it is necessary to emphasize the rational of the robot application in particular operations is principally conditioned by the manufacturing volume and the characteristics of the operations, which the robot (or more robots) needs to carry out[41]. Intelligent automation could then build upon the new capabilities of these advanced robots to achieve increased levels of autonomy and flexibility that in turn would enable manufacturers to respond to changes in a more efficient and cost-effective ways. Industrial automation deals primarily with the automation of manufacturing, quality control and material handling processes. China has become the fastest growing market for the automatic device industry and it continues to show great demand for industrial automation. The industrial automation being developed with the technology of today allows for a lot more flexibility than was available in the past. It is now relatively easy to mix automation with manual operations and the result will still be a continuous flow line. Therefore, parts or processes that do not lend themselves to automation can often be included in the line by utilizing an operator at that station. Lean Manufacturing has been a main focus in progressive manufacturing industrial strategies, where plants initially move from traditional Batch Manufacturing to Just In Time Manufacturing (JIT) or Continuous Flow Manufacturing (CFM). Many manufacturing companies transform their plans to an automated and integrated manufacturing facility. This transformation means that the plants invest capital in order to add automated processes and Computer Integrated Manufacturing (CIM) to their strategy. Within this strategy, the automation of material conversion, assembly operations and quality control processes can achieve significant benefits. The five primary reasons that dominate corporate tactical thinking are: reduce cost, improve quality, reduce inventory, improve response time and improve ergonomics.

i. Reduce Cost

When considering industrial automation as a cost reduction, management traditionally focuses on direct labour. Reducing direct labour is the most obvious method of reducing costs but this attempt must be analysed carefully. The important thing to remember is that eliminating direct labour results in a cost reduction only when the actual headcount is lower than what would be required to produce the same volume manually. When industrial automation does create an actual headcount reduction, the labour savings are usually specified as the entire cost reduction and other cost benefits are often overlooked. One frequently overlooked cost saving is the reduction of indirect labour since automation will generally reduce the amount of material handling and orientation time required with manual operations. Reduction of in-process inventory is another significant cost saving that occurs when automation replaces batch operations. Finished goods inventory can often be reduced as well. Another cost benefit of automation is scrap reduction since an automated line will inspect for parts present and will often integrate functional testing. In addition, defective piece parts are rejected by automated stations. Finally, when there is an automated line instead of individual workstations, the cost for training can be effectively reduced when it is necessary to add personnel.

ii. Improve Quality

There are a number of ways that automation will improve the quality of products. Two methods are the inspection of parts presented and the use of in-process testing. Any proper industrial automation will verify the presence and position of a part after it has been placed into the assembly. Often the equipment will incorporate in-process testing to verify that the product is correct before sending it to the next operation. Another quality improvement is the elimination of piece part rejects. A defective or out-of-tolerance part will usually not pass through the tooling required to automatically feed and load it. This sorting of rejects will improve the quality of the finished goods but it will also put pressure on the upstream operations to control the piece part quality. Industrial automation is often used to improve quality since machines can accomplish tasks that are difficult to do manually. For example, automation is frequently used to gauge and match components to achieve a more accurate fit than the primary processes will allow. When automation is used to test products, the parameters must be quantified and the products are accepted or rejected according to those parameters. This eliminates the subjective decision-making and potential for operator error, which is present when testing is done manually.

iii. Reduce Inventory

Industrial automation reduces inventory in exactly the same manner as Lean Manufacturing. Since product flows from station to station instead of sitting in bulk at each operation, the work-in-process inventory is dramatically reduced. In addition, the finished goods inventory can be reduced as automation permits production of products when they are needed.

iv. Improve Response Time

The response time is related to manufacturing cycle time, which is the time from receipt of an order to shipment of the product. When manufacturing in batch through a number of manual operations, most of that time is spent with the products sitting in buckets waiting for value added work to be performed. In a manner similar to Lean Manufacturing, automation will improve the response time as products flow from operation to operation. In addition, sub-assemblies can be integrated into the automation line in order to eliminate individual workstations. With the technology available today, flexible automation can further improve response time by processing small lot sizes or incorporating programmable changeovers. Another way that industrial automation can improve response time is by handling "surge" orders. When the automation project is developed, it should be planned to handle peak capacity. For example, if the equipment can produce the forecast annual quantity in two shifts, five days a week, a surge order can be run on a third shift or on the weekend. Without the automation, people would have to be added and trained in order to handle the peak volumes.

v. Improve Ergonomics

The impact of ergonomics is continually increasing when considering industrial automation. As people become aware of the problems associated with cumulative trauma disorders, vibration syndrome, fatigue, and so forth, they also become aware of the need to mechanize the operations that are causing these problems. Automation projects are often initiated when an operation is observed as "carpal tunnel waiting to happen". In most cases, the productivity gained by eliminating the difficult or repetitive operation will justify the expense of automation.

Industrial robots are vital tools allowing production at low cost and with high quality. Although robots are now widely used in mass production they still cannot be used cost-effectively for a wide range of production tasks in small and medium sized enterprises (SMEs)[42]. Robot automation technologies have mainly been deployed in capital-intensive large-volume manufacturing, resulting in relatively costly and complex robot systems, which often cannot be used in small and medium sized manufacturing. The primary quantifiable economic effect of robotics and programmable automation is a reduction in the real cost of manufacturing products made in small to medium batches as with producers of durable equipment. This raises several important questions. The first relates to how much of an impact robotics will have on the economics of batch production. The second relates to the extent to which improvements in productivity in the capital goods sector may impact the price of output in other sectors that purchase these capital goods[43]. Industrial robots have created a whole new ecosystem of high-paying and rewarding jobs. The jobs this "robot ecosystem" creates are typically high paying, rewarding and come with good levels of benefits. Industrial robots allow companies to remain cost competitive even while maintaining production in a high cost country as opposed to moving operations to a low cost country. This preserves jobs in the high cost countries that would otherwise be entirely shifted to the low cost countries. Research and development (R & D) efforts in robotics strongly contribute to the creation of new opportunities towards employment and growth. These opportunities are even more pronounced when taking into consideration apparent socio-economic factors such as the over aging of society, increasing the productivity of industries or progress towards a knowledge-based society. Robotics is able to address sustainable perspectives for all of these factors. Manufacturing employment increased in nearly every major industrialized country, even as the use of robotics increased sharply.

2.6 Innovation

Innovations have different degrees of novelty and frequently enter the market through unexpected opportunities, happenstance or even random events. A firm's introduction of an innovation developed elsewhere can have a significant impact on its performance but being an adopter is different from developing an innovation in house, especially if it is new to the market or to the world. Large firms tend to introduce more novel innovations than small and medium sized enterprises (SMEs). For product innovation, more than 50% of all large firms introduced a new to market innovation in Austria, Belgium, France, Greece and Luxembourg, while less than 25% did so in Hungary, Norway, Poland, the Slovak Republic, Turkey and the United Kingdom. Overall, SMEs are less likely to introduce novel innovations. Again, there are differences across countries. Within Europe, SMEs in France, Luxembourg and Sweden had a significantly higher propensity to introduce new to market product innovations than those in Hungary and Poland. The share of turnover from new to market product innovations can be used as an indicator of the impact of innovation at the company level. In most countries differences between SMEs and large firms in this respect are not very significant. However, in Germany the share of turnover from such innovations was on average more than four times higher for large firms than for SMEs. In Norway and Portugal, the relative share of turnover from new to market product innovations was significantly higher for SMEs than for large firms.

Technological innovations are usually associated with product and process innovation, whereas non-technological innovations are generally associated with organizational and marketing innovations. Technological and non-technological innovations are highly interconnected. The commercialization of technological product innovations often requires the development of new marketing methods. Similarly, a new production technique will typically increase productivity only if is supported by changes in organization. Taking into consideration the different impacts of and the interactions between technological and non-technological innovations is also important when formulating innovation policy. Technological and non-technological innovations, for instance, might differ in their impacts on company's performance (e.g. turnover, cost reduction and productivity) as well on socio-economic performance (e.g. contribution to growth and job creation). Policy tends to favor technological innovation, yet evidence suggests that success often also depends on accompanying non-technological innovation. Policy making agendas should therefore be broadened to take into account non-technological innovation. The innovation process depends essentially on external conditions; designing of new technologies results from interactions with customers, suppliers, competitors and various other public and private organizations. This explains why clusters, competition and other business linkages are so important for the process of technological development. In this context, innovation seen as a system, in terms of spatial, at the regional or national level, allows understanding and analysis of these interactions, with impact on innovation propensity and performance of innovation activity[44]. The introduction of market innovation of any kind is seldom a well-planned and systematically implemented process to achieve the maximum impact to the market. But even if it is well planned, commercialization of most market innovations may not succeed completely. Market factors that frequently seem obvious and were carefully researched may transform into major obstacles to market innovation, new technology or a new commercial product[45]. Innovation is the development of new products, services and processes, which may be based on cutting edge research. Firms innovate in a number of ways, including business models, products, services, processes and channels (Carr 1999) to maintain or capture markets, to outdistance competitors and to assure long-term growth and survival, especially in highly complex and turbulent environments (e.g. Eisenhardt and Brown 1999; Freeman 1994; Lawless and Anderson 1996). Considering these and other likely benefits of innovation, substantial research has examined innovations, focusing primarily on innovation typologies, research and development (R & D) economics and innovation diffusion (e.g. Freeman 1994; Van de Ven et al. 1999). A large body of evidence shows that innovative economies are more productive and faster growing. They deliver higher returns on investment and increased living standards. They are better at responding to changing circumstances through redeploying old activities and jobs. They are more able to find solutions to global challenges such as reducing dependence on fossil fuels, helping people live longer and healthier lives. Innovative businesses grow twice as fast, both in employment and sales as businesses that fail to innovate. Industrial innovation is the main agent to the rapid technological change. Some studies proposed the challenges while firms implementing mobile payment innovations such as the growth potential limitation for specific service positioning (Ondrus, et al., 2009), the lack of multilevel organizational involvement to develop platforms and shape sustainable ecosystems (Dahlberg, Bouwman, Cerpa & Guo, 2015; Gaur & Ondrus, 2012), and the conflicts in collaboration between firms (de Reuver, Verschuur, Nikayin, Cerpa & Bouwman, 2014). The emergence of evolutionary theorizing on innovation and corresponding system perspectives, has resulted in a shift in the design of innovation policy and its ensuing evaluation by focusing on behavioral additionality (Antonioli and Marzucchi, 2012; Gö k and Edler, 2012).

2.7 Industrialization

Industrialization is most commonly associated with the European Industrial Revolution of the late eighteenth and early nineteenth centuries. The onset of the Second World War also led to a great deal of industrialization which resulted in the growth and development of large urban centers as well as their suburbs. Industrialization is an outgrowth of capitalism and its effects on society are still to some extent undetermined, however it has resulted in a lower birth-rate and a higher average income. The process in which a society or nation transforms itself from a primarily agricultural society into one based on the manufacturing of goods and services. It is the process of converting to a socio-economic order in which industry is dominant. Individual manual labor is often replaced by mechanized mass production and craftsmen are replaced by assembly lines. Characteristics of industrialization include the use of technological innovation to solve problems as opposed to superstition or dependency upon conditions outside human control such as the weather, as well as a more efficient division of labor and economic growth. Industrial production creates job opportunities at higher skill levels, facilitates denser links across the services and agricultural sectors, between rural and urban economies and between consumer, intermediate and capital goods industries. Most of the countries that are now developed achieved that status in large part through a process of industrialization, involving a substantial shift of capital and labor into industrial activity and a rapid increase in the share of industrial value added in GDP during the development process. As a result industrialization occupies a central place in the rich tapestry of development theory and practice, although that place has varied as those theories and practices have changed over time[46]. Some regions and countries, notably in East Asia, are rapidly catching up with industrialized countries. Industrial development has had an important role in the economic growth of countries like China, the Republic of Korea, Taiwan and Indonesia. Technological change and innovations are essential sources of structural change. In Schumpeter's view, innovations lead to creative destruction, a process whereby sectors and firms associated with old technologies decline and new sectors and firms emerge and grow (Verspagen 2000). More productive and profitable sectors and firms displace less productive and less profitable ones and aggregate productivity in the economy increases. Technological change is thus at the very centre of modern economic growth. The industrial revolution originated in Great Britain during the 1700's and spread to other parts of Europe and to North America in the early 1800's. Industrial Revolution refers to the rapid development of industrialization that took place in the eighteenth and early nineteenth century in several parts of the world that brought great changes in the lives and work of people in these places. It increased enormously the production of many kinds of goods with the aid of power-driven machinery using mass production techniques. It also resulted in development of the factory system of production. Energy sources and technology in combination greatly impact the timing and location of industrialization.

The First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. Now, a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital and biological spheres. There are three reasons why today's transformations represent not merely a prolongation of the Third Industrial Revolution but rather the arrival of a Fourth and distinct one: velocity, scope and systems impact. When compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace. Moreover, it is disrupting almost every industry in every country; and the breadth and depth of these changes herald the transformation of entire systems of production, management and governance. The possibilities of billions of people connected by mobile devices, with unprecedented processing power, storage capacity and access to knowledge, are unlimited and these possibilities will be multiplied by emerging technology breakthroughs[47]. The emerging technology is the main drive to a nation's strategic industrial development that has become integral elements of business industry and commerce throughout the world. It plays a vital role in the current industrial situation which involves forward thinking and planning. It is a primary transformative formula that enables changes to take place in a wide range of sectors and brings broad-ranging impacts on many areas of life. International growth has become a matter of high importance even for the SMEs (Oseh, 2013). Internationalization has become increasingly important to the competitiveness of enterprises of all sizes. In today's environment, small and medium-sized enterprises (SMEs) that start with a global strategy can move quickly to take advantage of cross-border activities, which provide opportunities not only for revenue growth but also the exchange of knowledge and the enhancement of capabilities, which strengthen the long-term competitiveness of the firm (Wilson, 2013). Tahirou, Jouali & Arwata (2013) indicate that various factors including contingency, networking, information and external factors are critical for these organizations internationalization. They also reveal that government support, manager's motivational aspects, industry, geographic proximity, language similarity with other countries affect the internationalization of the firm. However, Villee & Curran (1999) that new trends and technologies continue to affect how business is conducted, which markets it serves and how it provides those services[48]. Small and Medium Enterprises (SMEs) are important to almost all economies in the world with her multitude of development challenges. The SMEs represent the biggest share in business establishments in practically all countries and play a key role in the industrialization of a developing country. They have unique characteristics on their own, as they are extremely flexible and can readily adapt to rapidly changing environment. Technology and energy are essential to industrialization, which is an advantage to Brunei Darussalam as the country has plentiful reserves of hydrocarbon for the development of technologically driven industries. Managing commercialization of high technology products needs a focused market target and strategy to be implemented and must take into consideration both the nature of the industry to be developed and its target market. This fine balance will be the primary factor that contributes to the success of a technologically driven industry. In technologically driven industries, as core technologies mature and mainstream customers proliferate, the primary source of customer value inevitably shifts from product innovation to business innovation that focuses on processes i.e. product development, procurement, manufacturing, sales, distribution or services, and marketing i.e. partnering, segmenting, positioning, packaging or branding. To meet the changing needs of customers, technology-driven companies must affect the corresponding shift in their own competencies. However, attempts to accomplish that through changes in strategy, structure, processes or rewards without changing the company's underlying cultural assumptions are almost always doomed to failure because culture strongly shapes both the competencies and rigidities of a company.

2.8 Conclusion

This Chapter suggests that a nation can foster its competitive capabilities and increase competitive advantage through the development of technology. The assimilation capabilities of the countries have a direct relationship to their technological levels. The development of the hi-tech industrial sector is viewed as the key driver of progress while the development of technology transfer is one of the core requirements to ensure continuous development of the domestic industries. Without technology and innovation, industrialization cannot occur and without industrialization development economic progress will not happen. Industrial innovation is the main agent for rapid technological change. Innovative technological developments on the other hand open new doors to completely new applications for industrial robots and automation. Finally, technology and energy are essential to industrialization; Brunei Darussalam has an advantage with its plentiful reserves of hydrocarbon for the development of technologically driven industries.

CHAPTER 3:

METHODOLOGIES

3.1 Summary

This research adopts multiple techniques, both inductive and deductive approaches, to explore and later analyze the significance of the theoretical drivers underlying the technology-based industrial development phenomena. SWOT-Analysis is conducted to identify the most profitable sustainable industry that is appropriate and feasible to advance in Brunei's emerging economic climate. It is a simple business methodology tool useful in this research for analyzing the strengths and weaknesses, and the opportunities and threats that help to focus on strengths, minimize threats, and take the greatest possible advantage from opportunities available in evaluating these studies. Relevant case studies are used to evaluate questions that provide recommendations from overall lessons learnt. The main limitation of these studies is the availability of sufficient and reliable data. These research limitations are the inherent methodology parameters that restrict the scope of research outcomes.

3.2 Methodology

The research adopts multiple techniques both inductive and deductive approaches to explore and later analyze the significant importance of the theoretical drive definition underlying the technology-based industrial phenomena. These mixed methods of research are considered as they give clear insight and owing to the requirement during the different phases of the research stages make specific demand on the general methodological approach. It is an effective tool. Tashakkori and Teddlie (2003, pp.11) define multiple methods as research in which more than one method or more than one worldview is used. The main reasons for the combination of methods in this research are firstly, to ensure findings in the traditional sense of seeking convergence of the results; secondly, to ensure complimentarity in the sense that a phenomenon may show overlapping and different facets and thirdly, to allow for initiation in which contradictions and fresh ideas and perspectives may emerge. Finally, applying different methods can add to the breadth and scope of studies while offsetting the weakness inherent to using each approach by itself. One of the most advantageous characteristics of conducting mixed methods research is the possibility of triangulation, i.e. the use of several means (methods, data sources and researchers) to examine the same phenomenon. (Tashakkori and Teddlie 1998):

triangulation – seeking to validate data and results by combining a range of data sources, methods or observers; creativity – discovering fresh or paradoxical factors that stimulate further work; and expansion – widening the scope of the study to take in contextual aspects of the situation. Adopting the qualitative method in this study rather provides an in depth understanding on intangible factors. This approach interprets the complex reality of technological transfer and implications of the quantitative data. Qualitative and quantitative methods should not be viewed as polar opposites (Van Maanen 1983) since their combination introduces both testability and context into the research (Kaplan and Duchon 1988). Collecting different kinds of data by different methods from different sources provides a wider range of coverage that may result in a fuller picture of the unit under study than would have been achieved otherwise (Bonoma 1985). **Triangulation enables identification of aspects of a phenomenon more accurately by approaching it from different vantage points using different methods and techniques.** Successful triangulation requires thorough analysis of the type of information provided by each method including its strengths and weaknesses. Such research techniques are used to continuously look at a research question from different angles and clarify unexpected findings and/or potential contradictions through the qualitative research approach. It develops a theory about the phenomenon of interest that provides a better understanding of the research problem than either of each alone to generalize findings from this qualitative research that eventually helps to explain findings[49]. The inductive approach starts with observations and theories that are formulated towards the end of the research and as a result of observations (Goddard & Melville, 2004). Inductive research "involves the search for pattern from observation and the development of explanations – theories – for those patterns through series of hypotheses" (Bernard 2011, pp.7). In other words, no theories would apply in inductive studies at the beginning of the research and the researcher is free in terms of altering the direction for the study after the research process had commenced. Neuman (2003, pp.51) affirms inductive research to begin with detailed observations of the world which moves towards more abstract generalizations and ideas. In other words, when following an inductive approach, beginning with a topic, a researcher tends to develop empirical generalizations and identify preliminary relationships as the researcher progresses through the research. Inductive approach “essentially reverses the process found in deductive research” (Lancaster, 2005, pp.25). Specifically, no hypotheses can be found at the initial stages of the research and the researcher is not sure about the type and nature of the research findings until the study is completed. It is noted that “inductive reasoning is often referred to as a “bottom-up” approach to knowing, in which the researcher uses observations to build an abstraction or to describe a picture of the phenomenon that is being studied” (Lodico et al, 2010, pp.10). In other words, in inductive studies no known theories or patterns need to be tested during the research process. Inductive reasoning is a logical process in which multiple premises all believed true most of the time are combined to obtain a specific conclusion based on experience learned. It deals in degrees to which given premises the conclusion has merit according to theoretical evidence. In this study, inductive reasoning is imperative for prediction and forecasting for which patterns, resemblances and regularities in experience are observed in order to generate theory or reach conclusions based upon evidence obtained. Unlike inductive reasoning deductive reasoning links statements with conclusion[50]. “The deductive approach is concerned with developing a hypothesis based on existing theory and then designing a research strategy to test the hypothesis” (Wilson, 2010, pp.7). This approach can be explained by the means of hypotheses that are derived from the propositions of the theory. In other words, the deductive approach is concerned with deducing conclusions from propositions. “Deduction begins with an expected pattern that is tested against observations whereas induction begins with observations and seeks to find a pattern within them” (Babbie, 2010, pp.52). It has been stated that “deductive means reasoning from the particular to the general. If a causal relationship or link seems to be implied by a particular theory or case example, it might be true in many cases. A deductive design might test to see if this relationship or link did obtain for more general circumstances” (Gulati, 2009, pp.42). Beiske (2007) informs that the deductive research approach explores a known theory or phenomenon and tests if that theory is valid in a given circumstances. “The deductive approach follows the path of logic most closely. The reasoning starts with a theory and leads to a new hypothesis. This hypothesis is put to the test by confronting it with observations that either lead to a confirmation or a rejection of the hypothesis” (Snieder & Larner, 2009, pp.16). Moreover, deductive reasoning can be explained as “reasoning from the general to the particular”

(Pelissier, 2008, pp.3), whereas inductive reasoning is the opposite. In other words, the deductive approach involves formulation of hypotheses and their subjection to testing during the research process while inductive studies do not deal with hypotheses in any ways. Thus, deductive reasoning observed to as possessing advantages of certainty and objectivity. This research is intended to be more exploratory as it explores specific aspects of technological transfer and does not aim to provide final and conclusive answers to research questions for which the direction of the study has been altered to a certain extent. It intends merely to explore the research questions and does not intend to offer final and conclusive solutions to existing problems. It is conducted in order to determine the nature of the problem not solely intended to provide the conclusive evidence but aids in gaining a clear insight into the problem. Saunders et al. (2007, pp.134) warn that when conducting exploratory research, the researcher ought to be willing to change his/her direction as a result of a revelation of new data and new insights. An exploratory research design does not aim to provide the final and conclusive answers to the research questions but merely explores the research topic with varying levels of depth. "Exploratory research tends to tackle new problems on which little or no previous research has been done" (Brown, 2006, pp.43). Moreover, it has to be noted that "exploratory research is the initial research which forms the basis of more conclusive research. It can even help in determining the research design, sampling methodology and data collection method" (Singh, 2007, pp.64). Sandhursen (2000) draw the difference between exploratory and conclusive research by stating that exploratory research will result in a range of causes and alternative options for a solution of a specific problem, whereas conclusive research will identify the final information that is the only solution to an existing research problem, i.e. statement about an area of concern. In other words, the difference between exploratory and conclusive research designs is that exploratory research design simply explores the research questions, leaving room for further research, whereas conclusive research design is aimed to provide final findings for the research which is not an intension for this research. It has been stated that "an exploratory study may not have as rigorous a methodology as is used in conclusive studies and sample sizes may be smaller but it helps to do the exploratory study as methodically as possible, if it is going to be used for major decisions about the way we are going to conduct our next study"

(Nargundkar, 2003, pp.41). Comparative research compares more cases with a view to discover outcomes for the cases being compared. This technique utilizes multiple disciplines in one study. When it comes to method, the majority agreement is that there is no methodology peculiar to comparative research[51]. "From the definitions given in the large body of literature on the subject, a study can be said to be cross-national and comparative if one or more units of two or more societies, cultures or countries are compared in respect of the same concepts and concerning the systematic analysis of phenomena, usually with the intention of explaining them and generalizing form them" (Hantrais & Mangen, 1996, pp.1-2). Comparative studies assist in this research study focus studies on the industrialization successes in the ASEAN Newly Industrialized Countries (NICs) comprise Indonesia, Malaysia, Philippines and Thailand that are best examples for adoption in the context of Brunei Darussalam owing to the fact that Brunei Darussalam is a member to the Association of South-east Asian Nations (ASEAN). NICs are countries whose level of economic development ranks them somewhere between the developing and first-world classifications. These countries have not yet reached a developed country's economic status and are undergoing a rapid economic growth. Incipient or ongoing industrialization is an important indicator of NICs. The term came into use around 1970, when the four Asian Tigers[52] of Hong Kong, Singapore, South Korea and Taiwan rose to global prominence as NICs in the 1970s and 1980s, with exceptionally fast industrial growth since the 1960s; all four economies have since graduated into advanced economies, i.e. developed countries that possess a high level of gross domestic product per capita, as well as a very significant degree of industrialization (IMF); and high-income economies, i.e. country with a gross national income per capita above US$12,735 in 2014 (World Bank) . There is a clear distinction between these countries and the countries now considered NICs. All four economies are classified as high-income economies (World Bank) and advanced economies by the International Monetary Fund (IMF) and US Central Intelligence Agency (CIA). All of them, like Western European countries, possess Human Development Index (HDI) that is considered very high (United Nation). Comparative method is used to ascend from the initial level of exploratory case studies to evolution for which differences become the main focus of examination. The goal is to learn from cases under study to reveal underlying variation factors.

It is an efficient and useful approach for explicating tacit knowledge by comparing several cases. It is also versatile as it can be used in detailed work as a complement to other methods or to the entire structure of a research study which can consist of the comparison of just a few cases. This technique reveals the systematic invariance that is true for the cases that were studied for which the goal is to generalize the findings. This approach contributes to policy improvement to the development of a relevant knowledge base of domestic policy in which we can put our judgments about policy processes and outcomes into a broader and more refined perspective, aware of alternatives and discover latent policy constraints and opportunities from review of others' experience.

3.3 SWOT-Analysis

SWOT-Analysis is conducted to identify the most profitable sustainable industry feasibly appropriate to advance in Brunei's emerging economic climate. This business methodology tool is a simple but useful framework considered in this research for analyzing the strengths and weaknesses, and the opportunities and threats that help to focus on strengths, minimize threats, and take the greatest possible advantage of opportunities available in evaluating this study. The flexibility of SWOT-Analysis allows its use with newer ideas (Dyson, 2004). For example, researchers recognize SWOT-Analysis as one of the techniques that could be used to help companies move toward the development of a knowledge strategy (Zack, 1999) and competitive knowledge (Gray, 2010). Work by Rothaermel (2013) supports these strategies by arguing that the insights synthesized from a SWOT-Analysis increase the chances of gaining a competitive advantage in a business' marketplace. Competitive advantage is a business concept describing attributes that allow an organization to outperform its competitors. These attributes include access to natural resources, such as high grade ores or cheap energy sources, highly skilled manpower, geographic location, high entry barriers, etc. New technologies, such as robotics and information technology, also provide competitive advantage, whether as a part of the product itself, as an advantage to the making of the product, or as a competitive aid in the business process. "Competitive advantage attempts to correct for this issue by stressing maximizing economies of scale in goods and services that garner premium prices (Stutz & Warf 2009)"[53]. In Porter's view, strategic management should be concerned with building and sustaining competitive advantage[54]. The term competitive advantage refers to the ability gained through attributes and resources to perform at a higher level than others in the same industry or market (Christensen & Fahey 1984, Kay 1994, Porter 1980 cited by Chacarbaghi & Lynch 1999, pp.45)[55]. The study of such advantage has attracted profound research interest due to contemporary issues regarding superior performance levels of firms in the present competitive market conditions. "A firm is said to have a competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential player" (Barney 1991 cited by Clulow et al.2003, pp. 221)[56]. SWOT-Analysis is an advantageous tool for providing qualitative information in an organized fashion. Weihrich is often recognized as the first person to identify the advantages of using this tool (Friesner, 2011). Weihrich's (1982) research discusses the framework as a way for companies to list threats, opportunities, weaknesses and strengths (TOWS) for identifying relationships and creating strategies. Using this approach makes it possible for strategy formulation or in a more sophisticated way as a serious strategy tool. Successfully implemented strategies will lift a firm to superior performance by facilitating the firm with competitive advantage to outperform current or potential players (Passemard & Calantone 2000, pp. 18)[57]. It aims to identify the favourable and unfavourable internal and external factors to reach the goal and develop short-term and long-term strategies. The SWOT framework model has been presented by many as a clear and straight forward way to depict information about a company from an internal perspective through strengths and weaknesses and from an external perspective through opportunities and threats (Hill & Westbrook, 1997; Coman & Ronen, 2009). The flexibility of SWOT-Analysis allows companies to display different combinations of the strengths, weaknesses, opportunities, and threats (Ghazinoory, Abdi & Azadegan-Mehr, 2011). These different combinations provide multiple viewpoints and offer a starting point for strategic planning (Helms & Nixon, 2010). Additionally, the information from SWOT-Analysis can identify factors that are an important part of a decision making process (Yüksel & Dagdeviren, 2007). SWOT-Analysis is one of the most used tools assisting a company in defining actionable strategies (Coman & Ronen, 2009). It is not intended to be used as an end in itself, but as part of an ongoing process for strategy development (Dyson, 2004). Using the results maximize the positive influences and minimize the negative factors to turn SWOT-Analysis results into strategies by looking at the strengths identified, and then come up with ways to use those strengths to maximize the opportunities, these are strength-opportunity strategies. Then, look at how those same strengths can be used to minimize the threats identified; these are strength-threats strategies. Continuing this process, use the opportunities identified to develop strategies that will minimize the weaknesses, weakness-opportunity strategies[58]. "SWOT-Analysis is recommended in the research by both Zack (1999) for creating knowledge strategy and by Rothaermel (2013) for increasing a company's competitive advantage".

3.4 Case study

Case study carried out relevant to evaluation questions that provide recommendations from overall lessons learnt through this research study. Case study is a specialist work of writing in contrast to reference works[59] that provide rich qualitative data and have high levels of ecological validity for which this approach is chosen to aid this research. It is a method of learning about a complex instance through an extensive description and a contextual analysis that allows the exploration and understanding of complex issues. Thus, a case study approach can be considered a robust research method particularly when a holistic and in-depth investigation is required. Case study is an ideal methodology when a holistic, in-depth investigation is needed (Feagin, Orum & Sjoberg, 1991). Further, this method is designed to bring out the details from the viewpoint of the participants by using multiple sources of data. The benefits of this qualitative approach are that the information is richer and has a deeper insight into the phenomenon under study for which the qualitative data is obtained from the action research, i.e. this can either be research initiated to solve an immediate problem or a reflective process of progressive problem solving to improve the way they address issues and solve problems. Denscombe (2010, pp.6) writes that an action research strategy's purpose is to solve a particular problem and to produce guidelines for best practice. Kurt Lewin, then a professor at MIT, first coined the term "action research" in 1944. In his 1946 paper "Action Research and Minority Problems" he described action research as "a comparative research on the conditions and effects of various forms of social action and research leading to social action" that uses "a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action". Qualitative case study facilitates exploration of a phenomenon within its context using a variety of data sources. This ensures that the issue is not explored through one lens but rather a variety of lenses, which allows for multiple facets of the phenomenon to be revealed and understood. Qualitative data are types of information that contain aspects that are non-measurable and merely approximations. Such an approach would not promote the general target of research but it can motivate for various reasons. As in any other qualitative study the data collection and analysis occurs concurrently. Case study is known as a triangulated research strategy. Snow and Anderson (cited in Feagin, Orum & Sjoberg, 1991) asserted that triangulation can occur with data, investigators, theories and even methodologies. Stake (1995) stated that the protocols that are used to ensure accuracy and alternative explanations are called triangulation. Triangulation is used to indicate that two or more methods are used in a study in order to check the results of one and the same subject. "The concept of triangulation is borrowed from navigational and land surveying techniques that determine a single point in space with the convergence of measurements taken from two other distinct points"[60]. The idea is that one can be more confident with a result if different methods lead to the same result. It is a powerful technique that facilitates validation of data through cross verification from two or more sources that refers to the application and combination of several research methods in the study of the same phenomenon[61].The need for triangulation arises from the ethical need to confirm the validity of the processes[62]. As an alternative to quantitative or qualitative research, case study is a practical solution that is a good method to challenge theoretical assumptions. This research strategy has various advantages as it investigates a phenomenon of real-life situations that provides a better understanding on issues under investigation.

3.5 Research Scope and Limitations

The bottom line of this research intends to provide the basis for many government policies on how the technology transfer can occur in the Brunei Darussalam industrial context. The main limitation is the availability of sufficient and reliable data. These limitations are the inherent methodology parameters that restrict the scope of the research findings and are outside the control. These reservations, qualifications and weaknesses arise when all variables cannot be controlled or the optimum number of samples cannot be taken due to various constraints. Therefore, these factors reduce studies' validity of results, i.e. the credibility of the findings. In this qualitative research the needs to think about the relationship between the issue under investigation and the method used is a crucial process that would be unusual in quantitative research. Underpinning this consideration is the philosophical question of the nature of the relationship that exists between theory and any empirical observation; i.e. results that support the hypothesis together with the associated problem of research purpose in collecting and analyzing the data. As Andrew Bennett and Colin Elman have noted, qualitative research methods enjoy "an almost unprecedented popularity and vitality in the international relations sub-field", such that they are now "indisputably prominent if not pre-eminent" (2010:499)[63]. Every case has its own characteristics from the holistic perspective with a different history and culture, and therefore cannot be compared and comparative study cannot be exempted. Considered as a whole every nation is unique, and 'holistic comparison' is thus impossible (Goldthrope, 1997:3). Methodological issues including data reliability, case-focus problem and defining problem of concepts are too complex to be completely accurate in this research. It is noted that "reliability problems crop up in many forms. Reliability is a concern every time a single observer is the source of data because we have no certain guard against the impact of that observer's subjectivity" (Babbie, 2010, pp.158). According to Wilson (2010) reliability issues are most of the time closely associated with subjectivity and once a researcher adopts a subjective approach towards the study then the level of reliability of the work is going to be compromised. The validity of research can be explained as an extent at which the requirements of the scientific research method have been followed during the process of generating research findings. Oliver (2010) considers validity to be a compulsory requirement for all types of studies. Validity is generally seen as an evaluative concept embracing not only the question of whether a researcher has followed established procedures but more substantively; "the quality and strength of the arguments that researchers put forward to substantiate claims about the reliability of their conclusions" (Avis, 2005:12). Validity seen in terms of the internal consistency draws attention to the ability to combine the empirical research data with an application of theory in order to explain particular phenomena rather than merely describe it. Appropriate methodological approaches have been chosen taking into account the natures under studies and most suitable cases for studies have been selected. It is fully understood that although threats to research reliability and validity can never be totally eliminated but only minimized, this threat as much as possible is always under consideration. Scope of discussions is a factor of limit owing to the lack of many years of experience in conducting research for which the scope and depth of discussions is compromised in many levels. SWOT-analysis is a single methodological approach that handles complex issues requiring more in-depth research and analysis to make decisions. This only covers issues that can definitely be considered a strength, weakness, opportunity or threat; it is difficult to address uncertain or two-sided factors, such as factors that could either be a strength or a weakness or both, with this approach. It is limited because it does not prioritize issues and provide solutions or offer alternative decisions. It generates too many ideas but it is not helpful in the selection of the best and it produces more information but not all is useful. Its simplicity does not provide a mechanism for solving any disagreements that arise from the discussion. The most obvious limitations are the risks of oversimplification; the fact that vested interests can prevent weaknesses and threats from being acknowledged and there is a danger of information overload, as there are no obvious limits as to what is and is not relevant. SWOT Analysis represents a very simplified view, which is used only as a basis for the formulation of the objectives, strategies and their implementation. It provides a separate understanding of the internal strengths and weaknesses and external opportunities and threats of business organization but it does not show us how external and internal factors are interconnected and what to do about them. Therefore, SWOT analysis cannot provide a proper framework for strategic analysis based on scenarios. It offers only a standard framework for further discussion. The SWOT analysis approach does not incorporate strategy aspects; it provides a starting place, not an ending place[64]. Case studies are not easy to replicate and subjective feeling influence research bias. Issues of anonymity and confidentiality create problems in presenting findings that it is difficult to present accessible and realistic pictures of that complexity in writing. The absence of systematic procedures for case study research is something that Yin (2009:14-15) sees as traditionally the greatest concern due to a relative absence of methodological guidelines. There is no simple check list of criteria, against which the validity and/ or quality of a piece of case study research can be judged (Phil Hodkinson & Heather Hodkinson, 2001)[65]. To Hamel et al. (1993) and Yin (1994), however, parameter establishment and objective setting of the research are far more important in the case study method than a big sample size.

The aim of technology localization is an important issue especially in developing countries that try to acquire new technologies but are facing limited technological capabilities. There is considerable time and financial constraints in adopting a technology transfer method to plan and implement technological strategies. The expenditure per Economically Active Population (EEAP) reflects the support of the Brunei government towards the development of a science and technology climate which is the main input to the development of the overall manufacturing sector that consists of various industries through advanced manufacturing and modern industrial technology approaches. The output per employee in the manufacturing sector or each specific industry reflects the technology and its sophistication employed in their production facilities. The value-added per employee in the manufacturing sector or each specific industry reflects the effectiveness of the human skills and technology employed in their production facilities. The national technology climate conditions and manufacturing technology climate conditions have direct influence on the growth of the specific industry in the state. The government transparency in industrial policy further reflects its seriousness in encouraging technology transfer to Brunei Darussalam. However, these influences may vary depending on the type of industry. In this research it has been assumed that they will have the same influence on all industries. The potential technological distance between the transferor and the transferee during the period of technology transfer is assumed to be the average value Political, social, cultural, language, religious and legal factors may impact the effectiveness of the technology transfer process. Some of these factors act as stimulants and some as barriers to the transfer process, they are all limiting factors defined through this research.

3.6 Conclusion

The goal is to learn from the cases studied to reveal underlying variation factors. This technique reveals the systematic invariance that is true for the cases that were studied for which the goal is to generalize the study outcomes. Using the SWOT-Analysis approach makes it possible for the formulation of strategy or in a more sophisticated way as a serious strategy formulation tool. Using the results we have attempted to maximize the positive influences and minimize the negative factors to turn SWOT-Analysis results into strategies by looking at the strengths identified, and then come up with ways to use those strengths to maximize the opportunities, these are strength-opportunity strategies. Then, look at how those same strengths can be used to minimize the threats identified; these are strength-threats strategies.

CHAPTER 4:

ANALYSIS, DISCUSSIONS AND STUDY OUTCOMES

4.1 Summary

Hi-tech industries are important for national and regional economic development; these sometimes equated with high wage jobs involving advanced methods and the most modern equipment that are environmentally friendly due to being less polluting than other industries. Three areas of hi-tech industry are identified in this strategic SWOT-Analysis that provides a competitive advantage in promoting the hi-tech infrastructure in Brunei Darussalam. The outcome of this comparative analysis turns indicators into a strategic policy for selecting the most lucrative industry and the formulation of reliable industrial policies.

4.2 SWOT-Analysis: Development of Hi-tech Industries in Brunei Darussalam

Technology-based or Hi-tech industry continues to be at the forefront of the development of sustainable economies, it accounts for the largest share of employment, business activity and labor income of any main sector in the state's economic base. Studies on economic development often focus on the role of technology, for example, Varga[66] emphasizes the importance of high technology for regional development. Hi-tech industries involve advanced methods and the most modern equipment that are environmentally friendly because they are less polluting than other industries. The recycling industry exhibits the win-win properties of sustainable growth, generating employment and equity and being environmentally friendly. The U.S. congress states that state and local government leaders are attracted to high technology industries because of this sector rapid expansion and its presumed job-creating potential[67]. Hi-tech is therefore considered important in national and regional economic development and is sometimes equated with high wage jobs. Policy instruments for industrial development depend on the type of technology and innovation being targeted and the nation's level of development[68]. Abramovitz (1986) noted that technological advancement has preconditions, which he termed social capabilities and technological congruence but while social capabilities are factors within a country, technological congruence is a measure of relatedness between countries in matching resources, markets, consumer preferences, scales and capital intensities (Abramovitz and David 1996). Lall (1992) highlighted the role of capabilities at the firm or national level. The national technological effort is hard to measure but as a proxy, he suggested R&D expenditure, patents and technical personnel. He also noted that importing technology is necessary but must be done in such a way that countries can also gain the learning benefits from the innovative process. The concept of technology transfer is the assumption that the technology is readily available to be transferred but it is not. Barry Bozeman outlines three competing technology paradigms that govern technology transfer models in North America; the market failure paradigm, the mission paradigm and the cooperative technology paradigm. Government intervention, which figures in all three transfer paradigms to some extent but is formally assigned to the market failure paradigm in Bozeman's framework is intended to remove barriers to market access through industry de-regulation, R&D tax credits, trade agreements and so forth. The mission paradigm describes the strong link between government technology policy objectives and research and development. In this instance, government carries out research and development central to important national interest objectives. The cooperative paradigm signifies a strong role for both universities and government in technology development and transfer to the private sector. Bozeman suggests, "universities and government labs make, industry takes". The focus needs to shift from technology transfer to technology collaboration. The further the technological distance of a country from the global frontier, the more difficult it is to absorb information effectively into production systems (Keller, 2002). The most famous examples of economies that have assimilated technology and moved out of a low level of development are the four Asian Tigers while Japan also resorted to foreign technology to reconstruct. The four Asian Tigers are the high growth economies of Hong Kong, Singapore, South Korea and Taiwan. These successful industrialized entities consistently maintained high levels of economic growth since the 1960s fueled by exports and rapid industrialization that enabled these economies to join the ranks of the world's richest nations. Hong Kong and Singapore are among the biggest financial centers worldwide while South Korea and Taiwan are important hubs of global manufacturing in automobile-electronic components and information technology respectively. Since the 1997 Asian Financial Crisis, praise of the Asian Miracle has dwindled in academia[69], yet the Tigers still stand as rare examples of states which have successfully developed in a manner no one could have predicted

50 years ago; and at a considerably faster rate than any of the current efforts in third-world development. Are there lessons to be learnt from the rapid economic growth of the Tigers, from the 1960s through to the 1990s and do these have a practical application in contemporary development?[70] Three areas of Hi-tech industry are identified in this strategic SWOT-Analysis that provides a competitive advantage in promoting Hi-tech infrastructure in Brunei Darussalam. The outcome of this comparative analysis turns an indicative into a strategic necessity for selecting the most lucrative industry and the formulation of industrial policies.

4.3 Feasibility Study 1:

Industry in the field of Semiconductors / Industrial Fiber-optics

Strengths	**Weaknesses**
▪ Abundance occurrence of the silica sand which is one of the constituent element in the production of semiconductors or fiber-optics is an advantage to Brunei Darussalam	▪ Absence of the local expertise and knowledge of the state of art of know-how to implement strategies of developing such hi-tech industry
▪ Strong financial ability to effectively promote and develop advanced semiconductor or fiber-optic industry	▪ Inability of government policy to meet requirements in the field of hi-tech economy and environmental related issues seem not encourage to foreign investors
▪ Availability of basic infrastructure, sources of energy and a good system of transport to the port	▪ Hi-tech industry's capacity building efforts and direction of human resource management
Opportunities	**Threads**
▪ Coincide with the government's intention	▪ Long term consequences on both human

to diversify economic activities in the field of hi-tech	development strategy and the industrial direction plan
▪ Vast market opportunities within the ASEAN and the Asia-Pacific regions to supply producing countries with the semiconductor-based products for the manufacture of hi-tech accessories	▪ Unregulated and over exploitation from silica industry will cause serious environmental damage. Environmental conservation strategy and compliance of certain international acts are crucial
▪ Continuous demand of high quality fiber optics from manufacturing nations in the Asia-pacific region	▪ Silica dust can cause potential health defects. Exposure to silica dust can lead to obstructive pulmonary disease

Table 4.3: SWOT-Analysis for Semiconductors / Industrial Fiber-optics Industry

4.3.1 Semiconductors / Industrial Fibre-optics Industry

The semiconductor industry has a huge market. Semiconductors are America's number three manufactured export over the last five years and 2014 sales were US$172.9 billion and had 51 percent of the US$335.8 billion global market. The U.S. sales are estimated to grow five percent in 2016. The abundance of silica sand are seen as attractive to the semiconductor industry in Brunei Darussalam. The Brunei Economic Development Board (BEDB) is looking at the potential of developing silica sand industry. The Sultanate is said has an estimated reserve of 16.25 million metric tonnes of the silica material commonly used to make glass. According to the study carried out, silica sand is mainly deposited in ancient raised beach remnants on the Brunei coastal area that are found along the coastal area from Tutong to Muara but it is most extensive in the Tutong area. The silica sand at Tutong occurs as a flat terrace remnant some 11 kilometres long and up to 1.6 kilometres wide. The deposit is bisected by the main Seria-Tutong Road between Sungai Telamba in the west and Sungai Tutong in the east. The sand forms terraces rising to about 15 metres above MSL over relatively low, flat Recent/Quaternary clay with an average thickness of 3 meters. Local development of podzol soil occurs but in general the sand has very poor nutrient content and hence the terraces are largely devoid of vegetation except for shrubs and thin primary forests. Two types of sand are present: 1) an upper, fine white sand of excellent glass making quality, with variation in thickness between 0.6 to 4.6 meters, and; 2) an underlying, humus stained fine sand. Sieve analyses on the sands indicate that more than 90% consists of the ideal grains (36 + 100 mesh sieve sizes). The white sands are rather pure. Sample analysis by Wilford (1961) indicated that they consist of 99% silica (SiO_2) and less than 0.05% of iron (Fe_2O_3). Analysis by the Leerdam Glasfabrieken in the Netherlands in 1987 confirmed the purity quality (Fe_2O_3 0.015 weight %). The sand is suitable for manufacturing good quality glass but the Fe_2O_3level is too high for optical glass manufacturing. The silica sand deposits at Muara cover a total area of about 7.8 km^2. With an average thickness of 1.8 meters the reserves are roughly 15 million m^3 for the upper good quality sand and approximately the same amount for the poorer quality sands. A quartz sand deposit is located at Meragang, to the northwest of Muara Town. As in the Tutong area, the sand also forms a terrace, here at a height of 18-21 meters above MSL. Sample analyses (Wilford, 1961) indicate that the sand is of poor quality and less uniform than that at Tutong. Most of the sand has already been excavated for the Muara Deepwater Port and the Muara Road projects. This evidentially suggests that Brunei has a potential to develop its raw silica into a semiconductor industry that involves pre-fabrication, fabrication and post-fabrication verticals. The success of the semiconductor sector in India for example is a case that Brunei can learn from. In the last four years, India's semiconductor market has grown from approximately US$ 6.5 billion (2011) to approximately US$ 9.7 billion (2013). The demand for semiconductor solutions, the heart of the electronic systems, got a fillip as the consumption of electronic equipment in India grew at a CAGR of 29.8 percent from US$ 28.3 billion in 2005 to reach US$ 363 billion by 2015. Both the electronics and the semiconductor sectors are mutually beneficial for each other and the growth in one sector leads to growth in the other. The major semiconductor end-user segments have been communications, IT and consumer electronics. Semiconductors are poised to impact human life far more as they open up new possibilities in nano-sciences, biotechnology, medical sciences, electro-mechanical devices, photonics, remote sensing and so on. The semiconductor design requirements of such verticals provide an opportunity to multinational companies to invest in Brunei and tap the potential for which this small state possesses a great potential to become a regional hub. The reasons for the growth in the semiconductor industry is mainly due to the growth in the chip design industry, unprecedented growth in domestic consumption of electronic goods significant export potential for this industry increased semiconductor content in the electronic industry. Brunei Darussalam is financially strong so it can effectively promote the development of semiconductor industry. The Networked Readiness Index 2013 suggests that the state is ranked 57[71]. With abundant natural resources and a small population, Brunei Darussalam has one of the highest levels of GDP per capita in Southeast Asia. The presence of hydrocarbon as an energy prime mover is an encouraging factor that supports the semiconductor industry. The transport infrastructure is amongst the most developed in ASEAN countries. The country has an extensive network of roads and highways, and good access to Brunei deep water port as well as a developed aviation infrastructure. Telecommunication infrastructure is efficient with fast internet access. **Table 4.3.1** illustrates energy resources for Brunei Darussalam.

Resource	Value	Units
Wind Potential	0	Area(km^2) Class 3-7 Wind at 50m
Solar Potential	17,239,249	MWh/year
Coal Reserves	Unavailable	Million Short Tons
Natural Gas Reserves	390,800,000,000	Cubic Meters (cu m)
Oil Reserves	1,100,000,000	Barrels (bbl)

Table 4.3.1: Energy Resources

Despite much economic strength Brunei Darussalam has been left far behind when it comes to industrial technology and automation to foster the development of high-value-added manufacturing and production sectors. Its small population suggests that it needs a highly trained and skilled work force for which the absence of local experts is a serious deficiency in the development of silica-related and the downstream industries. The population of Brunei Darussalam was estimated to be 426, 444 people. This is an increase of 1.46 % (6 153 people) compared to the population of 420, 291 the year before. In 2015 the natural increase was positive, as the number of births exceeded the number of deaths by 5, 720. Due to external migration, the population increased by 433. The sex ratio of the total population was 1.020 (1, 020 males per 1, 000 females) which is higher than the global sex ratio. The global sex ratio in the world was approximately 1, 016 males to 1, 000 females as of 2015 (January 2016, JPKE, Brunei Darussalam). Government industrial policies are rather weak, given the requirements for the hi-tech economy and related environmental issues; the government is not attracting enough foreign investors. This government needs to attract foreign direct investment (FDI) and encourage multi-national companies to set up their firms in Brunei Darussalam. The government of Brunei Darussalam needs to focus and prioritize its Hi-tech industrys' capacity building efforts and direction of human resource management. Its small population also means that it has a good starting point for strong work force capacity building for government needs to look into R & D strategy to encourage the development of raw white silica into semiconductor end-products. There is no technology transfer and spillover of technologies to domestics firms. Brunei Darussalam needs to strengthen its human resource abilities. The feasibility of the development of the semiconductor industry is attractive as this coincides with the government's intention to diversify economic activities in the field of hi-tech. There are vast market opportunities within the ASEAN and the Asia-Pacific regions to supply producing countries with semiconductor-based products for the manufacture of hi-tech accessories. Brunei Darussalam's central location in South-east Asia means that it can position itself as a small-scale semiconductor manufacturer to balance trade among countries in ASEAN. The primary product of the semiconductor industry is Integrated Circuits (IC) – a set of electronic circuits composed of multiple transistors connected by wires on a plate of semiconductor material, usually silicon – which is an intermediary product composed of numerous smaller parts used in several consumer and industrial electronics. The value chains of semiconductor manufacturers start with Integrated Circuits (IC) design, and extend to wafer fabrication and assembly and testing. Most of the manufactures concentrate on assembly and testing process in Malaysia[72]. Collaborative efforts with other ASEAN governments will help to facilitate the development of the semiconductor industry and will continue to play essential roles in addressing crucial factors in human resource development and technological expertise. The semiconductor industry is seen as sustainable as there is continuous demand of high quality devices and fiber optics from manufacturing nations in the Asia-pacific region especially Korea, Taiwan and Japan for which Brunei Darussalam can set up a joint-venture project in this field, which indirectly will invite technology transfer to Brunei Darussalam. There is concern over silica dust that potentially causes health defects. Exposure to silica dust can lead to obstructive pulmonary disease but scientific evidence strongly refutes such claims. Silica sand mining has minimal environmental impact, involves virtually no public health risk, and is an important part of domestic energy production that has substantial economic benefits. Heartland Policy Study No. 137, "Environmental Impacts of Industrial Silica Sand (Frac Sand) Mining,". However, the unregulated and over exploitation from silica industry will cause serious environmental damage. An environmental conservation strategy and compliance of certain international standards are a crucial matter of great demographic concern in Brunei Darussalam.

4.4 Feasibility Study 2:

Industry in the field of Hi-tech Farming

Strengths	Weaknesses
▪ Conventional small scale and traditional farming has long been practiced; this can provide an excellent basis for a hi-tech	▪ Ineffective technical infrastructure that integrate between hi-tech agricultural management of farming and

farming industry	conventional farming
▪ Excellent equatorial climate is an essential pulling factor for the plantations of high value crops, tree plants or fruiting trees both for human consumption or medical purposes	▪ Less attention and exposure to hi-tech farming despite government's incentive in promoting agricultural industry to meet its domestic demands and for export purposes
▪ Strong financial ability to effectively promote and develop high-scale intensive farming industry through technological methods	▪ Lack of local expertise and knowledge of the state of art of know-how to implement strategies of developing a hi-tech farming industry
Opportunities	**Threats**
▪ Coincides with the government's intention to diversify economic activities through agri-tech business industry	▪ Hi-tech farming is a research-intensive industry. Many steps and prevention have to be undertaken prior to implementing high-tech farming
▪ Investment in hi-tech farming with proper selection of high value crops, tree plants or fruiting trees can easily invite foreign strategic partners both in research activities and in developing such industry	▪ Climate change is a primary problem and an un-controllable factor to certain crops, tree plants and fruiting trees that require certain effective technical strategies to ensure the harvesting period is not affected
▪ Continuous world's demand for certain high value crops, tree plants or fruiting trees will not only yield more agricultural	▪ Use of chemical fertilizers, pesticides sprayed, invisible pesticide and artificial

products but also will attract agri-tech innovation activities	growth hormones are issues to both human health and the environment

Table 4.4: SWOT-Analysis for Hi-tech Farming Industry

4.4.1 Hi-tech Farming Industry

Hi-tech farming or Agro-technology mainly refers to agricultural methods using the latest technology. There are minimal physical inputs to the system, but it is capital intensive since a large capital outlay is required to buy specialized equipment, maintenance, training of labor, etc. It's also a commercial farming system for which investment services both local and export markets; technical know-how is a must, for example, for hydroponics computers are used to monitor; it is labor-intensive because of the training of lab technicians, scientists, chemists and farm-hands; it uses farming technology to increase yields; it has high output and market value because the so-called hygienic (usually pesticide-free) conditions appeal to all health-conscious people, and it is dependent on research and development. Conventional small scale and traditional farming has long been practiced in Brunei Darussalam and hence provides an excellent base for Hi-tech farming industry's experiences to be introduced in its agricultural sector. The investment in the Hi-tech farming industry will deliver a systematic farming system that yields high production that in return will ensure high income to farmers. The farm produces vegetables, fruits and poultry products that are cheaper; and the space requirement for farming is less. It requires less land but will be able to produce more crops that will help to meet the ever-growing demand for food supplies. Singapore is the best example for which intensive Hi-tech farming is practiced; "Singapore's small but advanced vegetable farming industry is attracting Japanese firms that are eager to invest in or adopt its technology for use in Japan". Singapore has in recent years become a test bed for Hi-tech farming as the government encourages farms to explore innovative methods to overcome the chronic shortage of land and to reduce reliance on imports. The farm grows vegetables vertically in towers several meters high by means of a Hi-tech system that uses the movement of irrigation water to slowly rotate the plants, grown in trays of earth, so they get the right doses of sunlight and water. Singapore imports more than 90 percent of its food and has only a tiny farming industry that occupies about 200 hectares, less than 1% of its land area of 71,000 hectares. The farms focus on producing leafy vegetables, fish and eggs for local consumption (August 2014, Japan Times). Hi-tech farming is the key to food sustainability for Singapore. Since 1986 AVA Singapore (Agri-Food Veterinary Authority) has started hi-tech farming because of limited agricultural land in Singapore. The Hi-tech Farming needs less space for more products, less manpower, more hygiene and better crop quality. Singapore developed modern technology since 1986; to day over 200 agricultural firms in over six Agro-technology Parks manufacture Hi-tech products from Milk, Vegetables, Fish, Eggs and Fruit. The success story of Singapore in promoting its small-scale Hi-tech farming can be a best lesson to Brunei Darussalam in developing its Hi-tech farming industry with a focus on high-price crops or plants that has an export market. Agriculture, along with forestry and fisheries, contributes only 1% to the Brunei's total GDP (2010). The primary agricultural products include rice, vegetables, fruits, chickens, water buffalo, cattle, goats and eggs. The role of the agricultural industry has changed due to the growth of the oil industry, which has replaced it in terms of significance. With favorable employment opportunities in the oil sector, the number of people working in agriculture and the amount of land available to it has declined. Agricultural land accounted for only 2.1% of total land area in 2009, having stayed at a constant level[73]. In the agricultural sector the economically active population is an estimated 1 000 inhabitants, which is 0.5 percent of the total economically active population, of which 100 percent are male. In 2006, the gross domestic product (GDP) was US$11 471 million. In 2007, agriculture accounted for 0.69 percent of GDP. Some 55 percent of the cultivated land is under ruminant livestock production with the rest being horticulture, mixed cropping and poultry farming. Crop production is dominated by horticulture, which includes the cultivation of vegetables, production of fruits, floriculture and ornamental plants. Vegetable growing is mainly concentrated on the urban fringes while fruit orchards are scattered across the country. In 2003, almost 10 360 tonnes of mainly tropical leafy vegetables were produced. In the same year, crop production registered over 4 600 tonnes of fruits and nearly 547 tonnes of rice. Floriculture produces small quantities of orchid flowers and an assortment of tropical ornamental plants (MIPR, 2009). Brunei Darussalam gives great importance to agriculture and Agri-food development to ensure the security of the food supply and enhance economic contributions to the GDP. Agricultural development is the main factor that sustains national food supply and Agri-food production. For the past decade, there has been an impressive increase in the value of primary production from US$82.56 million in 1996 to US$158.98 million in 2005. In 2005, the livestock sector, including processed products, continued to dominate agricultural sector development with a market value of US$104.9 million. This is in comparison to the crop sector and its processed products which had an output value of U$54.08 million, contributing about 66 percent from livestock and 34 percent from crops to the total agricultural output. Poultry, eggs and leafy vegetables are commodities that have attained self-sufficiency level (MIPR, 2009)[74]. Brunei Darussalam has a tropical climate characterized by high rainfall and temperatures throughout the year. Climatic variations follow the influence of the monsoon winds. The northeast monsoon blows from December to March, while the southeast monsoon occurs around June to October. The total average annual precipitation is an estimated to be 2, 722 mm. There are two rainy seasons: from September to January and from May to July. The temperature is relatively uniform throughout the year, with an annual average of 27.9 °C, ranging from 23.8 to 32.1 °C. The drought months of March and April are the warmest. Owing to high temperatures and rainfall, humidity is high throughout the year with an average of 82 percent. This excellent equatorial climate is an essential pulling factor for the plantations of high value crops, tree plants or fruiting trees both for human consumption or medical purposes. There are many environmental benefits associated with Hi-tech farming that are unmatchable by conventional farming in terms of high production capacity where conventional farming is unable to produce maximal yields. Through better management of agricultural farms, much greater yields can be produced. The adoption of robotic technology in Hi-tech farming could help improve crop yields. A robotic system has been developed that utilizes an agricultural monitoring device for testing the quality of soil. It has the potential to reduce the environmental impact of farming. "With this novel instrument design we are tackling multiple challenges at once. First we have to miniaturize an instrument that is normally the size of a large wardrobe to fit on a small mobile robot so the measurements can be completed on-the-move. Second we are looking for nitrogen based fertilizer that can take multiple forms and is hard to measure accurately" (**Aron Kisdi, 2016)**. Increasing efficiency to 100% is not entirely feasible but implementing Hi-tech farming techniques would conserve resources and improve crop performance[75]. Ineffective technical infrastructure that integrates between Hi-tech agricultural management of farming and conventional farming is a potential risk factor in Brunei Darussalam. It is observed that less attention and exposure to Hi-tech farming is practiced in Brunei Darussalam despite the government's incentive in promoting agricultural industry to meet its domestic demands and for export purposes. This is mainly because farmers are not familiar with the concept of Hi-tech farming, and have poor knowledge of agricultural technology adoption and the traditional way of farming has always been viewed as the most convenient approach to local farmers. Lack of local expertise and knowledge of the state of art of know-how to implement strategies of developing Hi-tech farming industry is clearly an issue in the Brunei agricultural sector. Investment in Hi-tech farming with proper selection of high value crops, tree plants or fruiting trees can easily attract foreign strategic partners both in research activities and in developing such an industry. The robotic technology is already firmly entrenched as part of the modern farming industry and it's going to become more ubiquitous in the future. Continuous world's demand for certain high value crops, tree plants or fruiting trees will not only yield more agricultural products but also will attract Agri-tech innovation activities. With regard to Brunei Darussalam, the nature of its dense equatorial rain forest confers variety of high value crops, tree plants and fruiting trees; one example of these is the agar wood which grows wildly in Brunei's deep equatorial jungle. The Agar wood industry has the potential to be fully developed and commercialized in high volume production for raw materials and its downstream industries through Hi-tech farming approaches. Agar wood is one of the most expensive non-timber wood products of the world that has many uses in: cosmetics, incense production, medicinal sector and by the perfume industry. It grows wildly in the Brunei equatorial rain forest. First-grade Agar wood is one of the most expensive natural raw materials for which superior pure material can costs as much as US$100,000/kg., although in practice adulteration of the wood and oil is common, allowing for prices as low as US$100/kg.[76]. Oudh oil is distilled from Agar wood and fetches high prices depending on the oil's purity. The current global market for Agar wood is estimated to be in the range of US$6 - 8 billion and is growing rapidly[77]. One of the main reasons for the relative rarity and high cost of Agar wood is the depletion of the wild resource[78]. Hi-tech farming is a research-intensive industry; investment in the Agar wood industry can bring a significant return. Many steps and prevention have to be undertaken prior to implementing Hi-tech farming. Climate change is a primary problem and a un-controllable factor to certain crops, tree plants and fruiting trees that require a certain effective technical strategy to ensure that the harvesting period is not affected. Thus, commercially developing the Agar wood industry is seen advantageously over those issues. Use of chemical fertilizers, pesticides sprayed, invisible pesticide and artificial growth hormones are issues to both human health and environment. These are potential risks associated with Hi-tech farming if other crops or plants are to be considered.

4.5 Feasibility Study 3:

Industry in the field of Advanced Manufacturing Technology / Industrial Robots

Strengths	Weaknesses
▪ Strong financial ability to effectively develop and expand hi-tech production and utilization of industrial robot for domestic manufacturing sectors and to support petroleum-based industry's activities	▪ Low level of understanding in the implementation of strategies for the development of hi-tech production industry and utilization of industrial robots
▪ Capability to generate highly skilled and specialized manpower to work within associated technology's environment	▪ Low investment in up-to-date technologies and industrial robot both in capital terms and academia
▪ Intensive use of information technology is the basis to improve not only business operations but also increase the entire	▪ Lack of supply-chain articulation and infirm industrial design creativity

manufacturing process and reduce development time of new products	
Opportunities	**Threats**
▪ Coincide with the government's aspiration in adopting hi-tech as a mean to improve productivity	▪ Adverse economic factors and deficient public policies sought for continuous periodical reviews
▪ Growing market demand and better market share owing to better overall production capacity	▪ International competition and competitive issues
▪ Stimulate economic growth rate and promote development of more environmentally efficient technologies	▪ Costly up-scaling of processes and application of precautionary principle when faced with new technologies

Table 4.5: SWOT-Analysis for Advanced Manufacturing Technology / Industrial Robots

4.5.1 Advanced Manufacturing Technology / Use of Industrial Robots

Advanced manufacturing Technology (AMT) involves the innovative integration of new technology, production processes and management techniques with the workforce, organization and culture of the enterprise to form a total system of enhanced production[79]. Indeed, the advanced manufacturing movement, in tandem with the information technology revolution, is transcending the traditional parameters of mass production, giving rise to a new era in manufacturing in which manufacturers are increasing the speed and flexibility of production while improving product quality and customization (Mohanty, 1999). The benefits of AMT use are far ranging from increasing productivity, to improving flexibility, to producing higher quality products, to reducing production costs (Beaumont and Schroder, 1997; Rischel and Burns, 1997; and Small, 1998). Such advanced technological instruments will enhance the Hi-tech production capability and utilization of industrial robots will be beneficial for domestic manufacturing sectors to support petroleum-based industry's activities in Brunei Darussalam. Some researchers found factors that can influence the rate of success in the implementation of AMT include degree of investment, context of organization (organization culture and organization structure), strategic orientation, entrepreneurial environment (type of ownership, experience and education), external factors (government, supplier, customer and technology trend), manufacturing strategy, role of management information system department, justifying, planning and installing[80]. The adoption of AMT requires a high level of initial investment and also the level of risk associated with the implementation of the AMT projects but with its strong level of wealth Brunei Darussalam is capable to transform its manufacturing sector into a Hi-tech driven industry. The spin-offs from labor intensive conventional manufacturing to industrial automation and robotic control will enhance local manufacturing ability to introduce new products faster, more frequently and of higher quality is a distinct competitive advantage. Bringing new products to market faster has become a strategic imperative in many markets (Zirger and Hartley, 1996). Many companies are adapting agile manufacturing practices that refer to the capability to quickly go from a set of novel customer requirements to a quality, finished product (Kleiner, 1997). Productivity, the dominant competitive paradigm prior to the late 1970's, has been replaced by quality (Haddad, 1996). Effective product development minimizes the resources (people, money and time) required to provide an appropriate mix of product features, performance, quality, price and availability to customers (Zirger and Hartley, 1996). Brunei Darussalam is capable to generating highly skilled and specialized manpower to work within associated technology environments in related AMT disciplines. Workers are key elements in the running of a firm and as such play an important part in the firm's success in attaining its objectives. Human resources taken to be the pool of human capital under the firm's control in a direct employment relationship (Wright, McMahan and McWilliams, 1994:304), can provide the firm with a source of competitive advantages with respect to its rivals. Education significantly plays an important role in the development strategy of key technologies and human resource capacity building. There are two universities in Brunei Darussalam namely: the

University of Brunei Darussalam which was established in 1985 with missions – to educate, to conduct research and to serve to the broader community and the University Technology Brunei. Brunei Darussalam also established the formation of Brunei Polytechnic, a technical college since 2008 and the formation of Brunei Institute of Technical Education, which is an autonomous post-secondary educational institution. All these academic establishments are important avenues for gaining formal skills to train and educate work forces. If local academic facilities are not available then the government pays for overseas education. The Brunei government through the Ministry of Industry and Primary Resources has introduced industrial development plans to attract foreign multinationals to invest in high technology industries. The government's effort towards building infrastructure for ICT continues. The Authority for Info-communications Technology Industry (AITI) which is a statutory body was established on 1 January 2003 by the AITI Order 2001 to function as telecommunications regulator, national radio-frequency spectrum manager and developer of Brunei Darussalam's ICT industry. Intensive use of information technology is the basis to improve not only business operations but also enhance the entire manufacturing process and reduce development time of new products. However, the low level of understanding in the implementation of strategies for the development of the Hi-tech manufacturing sector and utilization of industrial automation is a prime issue. Brunei Darussalam needs to collaborate with established industrialized nations for example learning from the success of Germany. Germany has one of the most competitive manufacturing industries in the world and is a global leader in the manufacturing equipment sector. This is in no small measure due to Germany's specialization in research, development and production of innovative manufacturing technologies and the management of complex industrial processes. Germany's strong machinery and plant manufacturing industry, its globally significance level of IT competences and its know-how in embedded systems and automation engineering mean that it is extremely well placed to develop its position as a leader in the manufacturing engineering industry. Low investment in up-to-date technologies and industrial robots, both in capital terms and academia discourages the development of the AMT sector in Brunei Darussalam; a shift towards AMT coincides with the government's aspiration in adopting Hi-tech as a means to improve productivity. The challenge for government policy is to develop research links between industries, academia and government authorities. The nature of Brunei's small economy results in a lack of supply-chain articulation and infirm industrial design creativity. The demand for industrial robots has accelerated considerably due to the ongoing trend toward automation. Between 2010 and 2014, the average robot sales increase was at 17% per year globally (International Federation of Robotics, 2015) that reflects the significant importance of industrial automation for which there is growing market demand and better market share owing to the better overall production capacity that Brunei Darussalam can greatly benefits from. Implementation of AMT in Brunei's industrial sector will stimulate economic growth rate and promote development of more environmentally efficient technologies to overcome problems associated with traditional manufacturing systems. However, adverse economic factors and deficient public policies sought for continuous periodical reviews. Wiarda (1987) has suggested various subgroups of technologies within AMT and classifies them as systems, devices, stations and integrated and managerial systems. The systems, devices and stations mainly include automated identification stations, automated inspection stations, automated material handling devices, computer aided design work-stations, computerized numerical controlled machine tools, numerical control machine tools, programmable production controllers, robots and shop floor control systems. The integrated and managerial systems mainly include computer-aided manufacturing, computer aided engineering, statistical process control, production planning/inventory management software, engineering data management, computer-aided process planning, local area networks and group technology. The key to survival and prosperity of small businesses in this decade and beyond will likely rest on their ability to successfully exploit and benefit from the rapidly developing field of information processing in manufacturing (Safizadeh, Raafat & Davis, 1996). Cornwall (1976, 1977) saw technological change in certain manufacturing sectors as a driving force for productivity growth in several other sectors. Syrquin (1986) observes that, when overall growth accelerates, manufacturing typically leads the way and grows faster than other sectors. The micro-computer, which is an easier-to-use and less costly alternative to a mainframe, has spurred the trend that Lincoln and Warberg (1987), describe as small businesses entering the Hi-tech world. Garsombke and Garsombke (1989) studies 144 small and medium-sized manufacturing firms in

Maine to analyze the relationship between technology use and inhibitors to new technology implementation. They documented that firms that had adopted new technologies experienced improved performance in the areas of increased production output, reduced lead time and great profitability. They report, however, that automation technologies and performance are not linked, as one would have expected. Their research does identify lack of investment capital as a major barrier for small manufacturers wishing to adopt new technology.

4.6 Study Outcomes and Comments

This SWOT-analysis helped to develop a good understanding of the feasibility for selected Hi-tech industries relevant to Brunei's industrial situation that can be an important tool in decision-making for selecting the highest return Hi-tech industry. The SWOT-analysis provides a good framework for reviewing Brunei's industrial strategy; industrial direction, and how relevant government bodies and private firms can cooperate to lead the development of contingency plans which solely focus on technology transfer for the most highly profitable Hi-tech industry being considered. Companies undertake the major part of technology transfer and need to prepare their infrastructure and human skills for successful localization through technology transfer. Hence, the most frequently identified factors are dependent upon companies (Wikstrom and Norman, 1994; Naito, 1998; Barclay, 2005). Government policies could accelerate localization and aid companies in developing their new products based on transferred technology. On the other hand, lack of government support may cause the failure of technology and the company or create barriers to further development. Government policies providing demands for new products in the market and legislating supportive regulations for the localization of technology are of great importance to companies (Bennett and Zhao, 1997). Significantly, industrial growth strategy can also be formulated to accelerate the drive towards an industrial transformation from no technology to the Hi-tech industrial sector by evaluating this analysis. Thus, it is a useful indication for the formulation of a draft action plan on industrial development strategies pertaining to Research and Development, Education and Training needs, Science and Technological awareness, technical infrastructure and environment. These elements are more impactful and must be prioritized. The contribution of education and human capital accumulation to economic growth is well documented. Some of this occurs through science and innovation. Investment in the education and training of researchers and other highly skilled workers is a major factor in determining the contribution that scientific research can make to scientific progress and innovation. Moreover, human capital is a key factor in the adoption of new technologies and the introduction of innovative practices. Creating, developing and diffusing new products and processes requires strong science and technology (S & T) skills as well as many non-research soft and entrepreneurial skills. There is an increasing emphasis on policy issues related to the availability of highly skilled labor, in particular highly skilled human resources in science and technology. Strong science and technology skills facilitate the uptake and use of new technologies, which drives innovation throughout the economy. This places a premium on both the quantity as well as the quality of highly skilled labor in the economy. The development of a well-educated, adaptable and technologically capable population generates highly skilled labor with a strong scientific orientation, such that they can apply research, science, technology, innovation and entrepreneurial skills that will guide Brunei's aspirations towards a technology-based industrial nation. Such analysis provides a thorough insight of essential factors that can influence industrial policies and plans to act upon when undertaking the industrial strategic planning process, debating future directions and assessing existing opportunities for different Hi-tech industries under discussion but such analysis is a qualitative measure, it is subject to interpretation. Successful experience from Germany Hi-tech industrial development and stories from the four Asian Tigers underlies industrial innovation in strategic fields suggests that relevant R & D programmes need to involve industry closely in their funding and management. Public-private partnerships for innovation promote co-operation between the public sector (government agencies or laboratories, local academia) and the private sector in undertaking joint research projects or in building knowledge infrastructures.The other lesson learned is what needs to be done to upgrade the technological capability and human resource capacity, to develop a stronger technology-base and to create a more skilled and technology intensive economy for Brunei Darussalam.

4.7 Conclusion

To conclude, the feasibility for the development of the semiconductor industry is attractive for Brunei Darussalam as the nation has a potential to develop its raw silica and this also coincides with the government's intention to diversify its economic activities into hi-tech related fields. Investment in hi-tech farming is considered with proper selection of high value crops, tree plants or fruiting trees can easily attract foreign strategic partners both in research activities and in developing such an industry. Finally, the implementation of advanced manufacturing technology can enhance the hi-tech production capability and utilization of industrial robots will be beneficial for domestic manufacturing sectors to support petroleum-based industry's activities in Brunei Darussalam.

CHAPTER 5:
CASE STUDIES

5.1 Summary

A case study method is adopted as the research strategy to explore reasons for success and understand the lessons learned by other economies. This study follows a qualitative approach to identify the factors that enable successful technology transfer to create an understanding that guides policy priorities. Identifying sectors of Brunei Darussalam that would benefit most from specific technology and selecting the most appropriate technologies are the first steps in the technology-transfer initiative that will facilitate the nation's aspiration to transform its economy from a hydrocarbon-based industry to the technology-based industry that promotes rapid industrialization. After assessing technology needs, the government of Brunei Darussalam can write a plan to deploy the technologies. A strategic long-term approach will allow the government, industry and foreign technical assistance programmes to take action effectively. A transparent and strategic technology-needs assessment and implementation plan can deliver benefits to the fullest extent in the technological development crucial for Brunei's industrial sector.

5.2 Case Study: Transfer of Technology

A case study method is adopted as the research strategy to explore reasons for success and draws the lessons learned. Robert Stake (1998) points out that crucial to case study research are not the methods of investigation but that the object of study is a case: "As a form of research, case study is defined by interest in individual cases not by the methods of inquiry used". Other researchers, such as Robert Yin (1994), place more emphasis on the method and the techniques that constitute a case study. Case studies suggest that substantial technology diffusion occurs due to FDI (Blomstrom and Kokko, 1997). Thus, this study follows a qualitative approach to identify the factors that enable technology transfer subsequently suggest policy priorities. Technology transfer is a highly complex process influenced by domestic and international factors. The end result for the recipient must be the ability to use, replicate, improve and, possibly, re-sell the technology. Transfer of technology is more than just the moving of hi-tech equipment from the developed to the developing world, or within the developing world.

Moreover, it encompasses far than equipment and other so-called "hard-technologies", for it also includes total systems and their component parts, including know-how, goods and services, equipment and organizational and managerial procedures. Thus, technology transfer is the suite of processes encompassing all dimensions of the origins, flows and uptake of know-how, experience and equipment amongst, across and within countries, stakeholder organizations and institutions. It is about the complex process of sharing knowledge and adapting technology to meet local conditions. Technology Transfer strengthens human and technological capacity, and promotes commercial markets for climate-friendly technology when successfully implemented in Brunei Darussalam. The development of new technologies has always been central in industrial activities. Webster's (1989, p.1872) offers just three definitions of technology, none of which sets definitional controversies to rest. Technology is defined as: 1) the science or study of the practical industrial arts; 2) the terms used in a science, technical terminology; and 3) applied science. None of the major works on technology transfer uses any of these definitions of technology. Works on technology transfer generally focus on technology as an entity, not a study and certainly not any specific applied science. The most common view of technology is a tool, and then discussions proceed as to just what type of tool qualifies as technology. The formation process of technological changes is on one hand rational, goal-oriented or optimal and on the other hand adaptive, cumulative and evolutionary (Christiansen, 2001). Schumpeter proposed a three-stage process of technological change: invention constitutes the first development of a scientifically or technically new product or process; innovation is accomplished when a new product or process is first commercialized or made available on the market; and finally, in the diffusion stage, a successful innovation becomes widely available (Jaffe, et al. 2002). Grubler (1999) gave the process of technological change a more life-cycle-like six-stage typology: invention, innovation, niche market commercialization (adoption), pervasive diffusion (diffusion), saturation and senescence (gradual deterioration of function characteristic). "Technologies are selected not only on the basis of technical or economic performance measures but also by prevailing socio-political and cultural norms, rules and preferences" (Christiansen, 2001, p.11). Technological changes are as well constrained by various kinds of barriers and inertia. A technology's successful diffusion depends not only on the value of the idea or innovation but also on intertwined socio-economic, technological and political factors. The main barriers to technology transfer are[81]:

a. Institutional: inadequate legal and regulatory frameworks, insufficient assessment of technology needs and implementation plans.
b. Political: instability and corruption.
c. Technological: inadequate infrastructure, lack of technical standards and supporting institutions, low technical capabilities and technology knowledge base.
d. Economic: instability, inappropriate subsidies, poor macro-economic conditions and non-transparent markets.
e. Information: inadequate access to technical and financial information and poor dissemination of information to technology users.
f. Financial: insufficient capital, financing instruments that favour traditional and large-scale projects, risks for foreign investors.
g. Cultural: consumer preferences and social biases.
h. Legal: uncertain ownership, lack of intellectual property-rights protection and unclear arbitration procedures.
i. Participation and consultation: lack of local participation and inadequate understanding of local needs.

Successful technology transfer addresses an environmental problem, "Does the project reduce green house emissions or help countries adapt to the effects of climate change? Will the project improve other environmental or social problems?"; build the market for environmentally-sound technologies, that "may work on a project level but does it improve the technology's ability to gain market share?"; if these are cost effective, "Is the technology worth buying or investing in? Can efficient operation be maintained? Has it been evaluated on a life-cycle cost basis?"; if they stand a real chance in the real world, "Is there enough accessible information about the technology? Is there adequate human, technological and institutional capacity to support a market in the technology? Is the technology politically acceptable? Is it replicable?"; and does it make other problems worse, "Will it create new or exacerbate existing environmental or socio-economic problems?" Technologies that meet these criteria have a good chance of creating a lasting market for which a successful technology transfer must overcome barriers. Unique conditions in every country rule out any generic approach to technology transfer. Identifying sectors of Brunei Darussalam that would benefit most from a technology and selecting the most appropriate technology are the first steps in the technology-transfer initiative towards the nation's aspiration to transform its economy from the hydrocarbon-based industry to the technology-based industry that promotes rapid industrialization. After assessing technology needs, the state can write a plan to deploy the technologies. A strategic long-term approach allows the government, industry and foreign technical assistance programmes to take action effectively. A transparent and strategic technology-needs assessment and implementation plan can deliver benefits to the fullest extend in the technological development crucial for Brunei's industrial sector.

5.3 Case Study 1: Technology Transfer for Electronic Industry in Thailand

The rapid expansion in its electronic industrial sector is evidence of Thailand's success in transferring foreign technology into the country. Thailand is considered as one of the newly industrialized country in the South-East Asian region with its emerging economy. Thailand had a 2013 GDP of US$673 billion (on a purchasing power parity [PPP] basis). Its economy is the 2nd largest in the South-East Asia after Indonesia. Thailand ranks midway in the wealth spread in South-East Asia as it is the 4th richest nation according to GDP per capita after Singapore, Brunei Darussalam and Malaysia. The electrical and electronics industry has played an increasingly important role in Thailand's economy. The government of Thailand has launched proactive investment policies and measures, which have attracted investments from many multi-national companies and led the industry to prosperity in Thailand. Investment promotion, development of science and technology capabilities and implementation of measures supporting the development of the electronics industry have been important components of the national development strategy[83]. The Government created several initiatives to promote technology transfer, diffusion and innovation. Several institutions and ministries addressed areas such as manpower training and education, establishment of incubators and science parks and provision of grants. The National Science and Technology Development Agency (NSTDA) established the Industrial Consultancy Services in 1992 to promote the use of local and foreign technical consultants and facilitate the formation of alliances. In 1997, the National Science and Technology Development Agency set up the Software Park Thailand (SPT) to promote innovation and facilitate development of start-up firms. Furthermore, the Board of Investment also developed the Unit for Industrial Linkage Development (BUILD) programme to encourage the development of support industries, strengthen linkages and help small and medium-sized contract manufacturers improve their productivity and facilitate cooperation between foreign and domestic firms[84]. These policies have played a vital role in making Thailand a major manufacturer of electronic products and facilitated the acquisition of the skills needed to operate and manage production facilities to assemble intermediate and final electronic products. They have also played an important role in encouraging the development of local contract manufacturers and the transfer and development of technologies. The investment agencies and the science and technology institutions have played a critical role in the industrialization of Thailand. The investment policy measures developed by the Thailand Board of Investment (BOI) promoted Thailand as a favorable destination for export-oriented foreign direct investment[85]. On the other hand, the science and technology policies facilitated transfer of technology and promoted the development of the technological base. The international competitiveness of the Thai electronics industry has largely been based on successful acquisition and adaptation of foreign technology[86]. Thailand has successfully established and maintained effective access to external sources of technology necessary for building the technical, organizational and management skills needed to produce and distribute products and services efficiently. This has mainly been achieved through appropriate incentives to attract FDI and promote trade. FDI is an efficient channel for acquiring advanced technologies, as the investor may meet the cost of technology transfer, its adaptation and use. Investors may also introduce new managerial and marketing know-how. Thailand is a good example of a country that has exploited FDI and trade to acquire technology in its quest to industrialize. Thailand has been one of the major FDI recipients in South-East Asia over the past two decades (Brimble and

Sherman, 1999; Mephokee, 2002). In 2011, the electrical and electronics industry contributed almost 24% of Thailand's annual export revenues, generating US$55 billion. Major export destinations were ASEAN (17%), the EU (14%), China (14%), the US (13%), Hong Kong (12%) and Japan (11%). Thailand's robust manufacturing base and well-developed infrastructure, including an efficient road and ports system, make Thailand an ideal place for electrical and electronics operations. Currently, almost all of the major electrical appliance manufacturers are represented in Thailand. The Kingdom is not only a regional leader, but also a leader on a global level as Japanese, Korean, European and American multi-national companies manufacture electrical appliances in Thailand. In 2011, Thailand's main electronics exports were hard disk drives (HDD) and integrated circuits (IC), which accounted for approximately 34% and 26% of total electronics exports respectively[87]. The country holds a remarkable reputation in the IC and semiconductor industries, and boasts one of the largest assembly bases for these products in South-East Asia. Considering the increase in global demand for hi-tech consumer electronics, including computers, flat panel displays, tablets, gaming consoles and wireless devices, Thailand is the ultimate investment destination for the sector. Electronics investors are able to benefit from the strong growth in demand, as well as the comprehensive support from the government of this global hub, in the electronics world. Parallel to the rocketing demand for computers and mobile phones, the total value of Thailand's exported electronics amounted to approximately US$31 billion in 2011. The primary markets for these exports were China (18%), Hong Kong (17%), ASEAN (16%), the EU (14%) and the US (14%). Thailand has proven itself to be an extremely attractive location for the assembly and testing of HDDs, ICs and electronic sub-components. Although the electronics market in Thailand is mature and well-developed, there remain areas with high market potential that manufacturers considering to expand their market can explore. Currently, over 400,000 people are employed in Thailand's electrical and electronics sector[88]. They are a well-qualified but extremely affordable workforce that attracts many investors. Advancing the competitiveness and technical capabilities of the workforce has always been a main focus of the government of Thailand to ensure an adequate supply of qualified personnel for the industry. The Free Trade Agreements (FTA) between Thailand and various countries, such as Australia, New Zealand, India, Japan and members of ASEAN, gives Thailand and its foreign investors, a considerable advantage in reaching out to the different markets in the vibrant electronics industry. Under the ASEAN Free Trade Agreements (AFTA), most parts and finished electronics exported throughout ASEAN have been tariff-free since 2010. The establishment of the ASEAN Economic Community (AEC) in 2015 further enhanced Thailand's attractiveness. The AEC serves as a massive single market that is fully integrated into the global economy with equitable economic development. The 10 member states of ASEAN collectively offer close to 600 million consumers. The AEC open new doors to manufacturers by transforming ASEAN into a region with free movement of goods, capital, services, investment and workforce. Thailand boasts world-class infrastructure, including state-of-the-art ports, airports and communication facilities. The government of Thailand has been proactively encouraging the development of electronic clusters. Proximity between firms and their input suppliers within the clusters enhances communication and facilitates flow of goods. At the same time, clustering helps to reduce logistics costs through improved supply chain management[89]. Manufacturers also benefit from shared core technological innovations and human resource development programs. Thailand's electronics industry is the backbone of Thai manufacturing sector's success.

5.4 Case Study 2: Technology Transfer for Hi-Tech Agriculture in Peru

High-value export agriculture is an important element in the transformation of Latin America's economic growth strategy from import-substitution industrialization to competing in a global economy. This type of agricultural production shares with hi-tech industrial production a focus on innovation, skilled labor intensity and local conditions that favor price competitiveness. High-value agricultural exports not only require a relatively high level of skills in producing the raw output but also require skills in bringing these products to market quickly and in such a way that maintains high quality. With new information technology, it is possible for Latin American countries to become major players in distant markets. But this requires the capacity to take advantage of such opportunities. The success of asparagus cultivation (spring vegetable) in Peru is a good example to adopt in developing the hi-tech Agricultural sector. Peru is one of the world's fastest-growing economies with a 2012 GDP growth rate of 6.3%[90]. In 2007, Peru's net foreign direct investment was close to U.S. $5.3 billion (World Bank, 2009). This favorable business environment and relaxed land ownership rights have supported capable producers and agricultural entrepreneurs who have adopted state-of-the-art technology and organizational standards. Large scale exporters are fully aware of international market expectations. Many of them have founded or joined associations that can effectively promote their commodity, as the associations have a keen understanding of their respective industries, as well as world market conditions[91]. With open FDI, trade and capital flow policies and strong investor protections, Peru has created a highly competitive environment for firm strategy and rivalry. China has become Peru's largest trading partner following a free trade agreement with the People's Republic of China signed in April 2009[92] additional free trade agreements have being signed with the United States of America (2006) free trade agreement with the United States signed in April 2006[93], the European Union in June 2012. The European Union and Peru Sign Trade Promotion Agreement (TPA), with Japan free trade agreement which the constitutional monarchy of Japan signed in May 2011[94]. The early 1990s were a time when a new constitution and new laws encouraged Peruvian engagement in international trade and investment in Peru. These developments, along with Peru's natural advantages, such as a climate ideally suited for production of many horticultural crops, provided the ground-work for ongoing strong economic and export growth in traditional, as well as new, fruit and vegetable products. Trade and industry are centralized in Lima but agricultural exports have led to development in all the regions. Peru is a country with many climates and geographical zones that make it a very attractive agricultural nation. The production of asparagus is complex that requires skills in combining irrigation, fertilization and pest control in a way that increases yields at a competitive price. Shipping the product fresh, or processing it to meet international quality standards, and finding new markets for asparagus also requires developed country level skills. Despite this complexity and the skills it requires to compete internationally, Peruvian asparagus production increased enormously in the past 20 years. In 1985, a major Spanish asparagus grower moved from Spain to La Libertad, a region six hundred kilometers north of Lima to grow white asparagus on commercial scale there that was processed and exported for European markets. Prices and profits were high, and white asparagus cultivation began to increase rapidly. The area planted in La Libertad grew to 10,000 hectares in 1990 and 22,000 hectares in 2000. Productivity also increased with better fertilizing and irrigation. The mid-1980s also saw the introduction into Peru of green asparagus into the areas of Ica and Canete, about 200 kilometers south of Lima. The green asparagus was introduced by a United States Agency for International Development project that brought Peruvian agronomists to California to study different varieties. The Ica region rapidly became one of the world's largest producers of green asparagus. Asparagus production in a non-temperate climate is complex. In Peru, growers plant asparagus in desert areas, where temperatures are never excessively high. Growers use irrigation to produce an asparagus crop in the same manner as in a temperate area, and even use the irrigation system to simulate lower temperatures needed by the asparagus plants to regenerate growth. This technique permits two or more crops per year and allows harvesting at any time of the year because of the near constancy of the climate but it does require well-managed irrigation systems. Peru's sandy soil also provides advantages because of its porosity but that soil requires the right mixture of fertilizers, since it contains few of the nutrients needed to grow asparagus and other crops. In sum, Peru has many of the right natural conditions for asparagus production, but these natural conditions require the right technology to take full advantage of them. Peru is the only country in the world that harvests asparagus year round, with two or sometimes three harvests per year per field. The large-scale growers tend to run farms with state-of-the-art technology, such as drip irrigation. They can manipulate the harvest seasons by withholding water to the plants, which enables Peru to target the most profitable market periods. Peru has the world's highest asparagus yields, increasing steadily and almost doubling since 1990 (MINAG, 2010)[95]. Exports By 1994, Peru shared the title of world's largest asparagus producer with the United States, each country harvesting about 100 thousand metric tons. Approximately 95 percent of total Peruvian production goes to export (both fresh and processed), making Peru the largest asparagus exporter in the world. Peruvian exports to the rest of the world grew from 10 million pounds in 1980 to 187 million pounds in 1996 and continued to expand until 2000, when it peaked at about 220 million pounds. Peru produces both green (preferred in the United States) and white (preferred in Europe) asparagus. A Ministry of Agriculture census of the asparagus industry, taken in 1998 (near the height of the asparagus boom in Peru)[96] shows a total of 2,134 asparagus farms in the country, about 54 percent in the provinces of La Libertad and another 13 percent in Ica. These farms employed more than 20,000 workers, almost one thousand of them professionals and, of those, more than four hundred agricultural engineers (MINAG, 1998). More than 70 percent of the industry's employment is in La Libertad and Ica. Almost one-half of all employment as reported by the census is on large (more than 50 hectare) farms in those two provinces[97]. The Peruvian Institute for Asparagus and Horticultural Crops (IPEH) is a non-profit association of asparagus producers and exporters founded in 1998 to promote research, marketing, extension and international standard compliance. Peru's combination of business climate, trade preferences, low labor costs, and climatic conditions helped lay the foundation for developing a competitive and successful agricultural export industry.

5.5 Case Study 3: Advanced Manufacturing Technology in Norway

Norway's modern manufacturing and welfare system rely on a financial reserve produced by exploitation of natural resources[98]. The petroleum industry accounts for around a quarter of the Norway's gross domestic product (GDP)[99]. On a per-capita basis, Norway is the world's largest producer of oil and natural gas outside the Middle East[100]. The country has the fourth-highest per capita income in the world on the World Bank and IMF lists[101]. From 2001 to 2006, and then again from 2009 to 2015, Norway had the highest Human Development Index (HDI) ranking in the world[102]. The state has large ownership positions in key industrial sectors, such as the strategic petroleum sector, hydroelectric energy production, aluminum production, the largest Norwegian bank (DNB) and telecommunication provider. The government controls 31.6% of publicly listed companies. When non-listed companies are included the state has an even higher share in ownership mainly from direct oil license ownership. The emergence of Norway as an oil-exporting country has raised a number of issues for Norwegian economic policy. There has been concern that much of Norway's human capital investment has been concentrated in petroleum-related industries. Critics have pointed out that Norway's economic structure is highly dependent on natural resources that do not require skilled labor, making economic growth highly vulnerable to fluctuations in the demand and pricing for these natural resources. The Government Pension Fund of Norway is part of several efforts to hedge against dependence on petroleum revenue. Because of the oil boom since the 1970s, there has been little government incentive to help develop and encourage new industries in the private sector. Norway manufacturing increased in response to energy volume and price shocks. However the last decades have started to see some incentive on national and local government levels to encourage formation of new mainland industries that are competitive internationally. In addition to aspirations for a hi-tech industry, there is growing interest in encouraging small business growth as a source of employment for the future. The Norwegian economy's strong competitiveness is built on openness and transparency with policies that support dynamic trade and investment. The quality of the legal and regulatory framework is among the world's highest, institutionalizing the effective rule of law. The application of computers and especially of Advanced Manufacturing Technologies (AMT) in the production process has brought about an industrial revolution over the last twenty years. The introduction of new technologies such as CAD, NCICNC machines, robots as well as new manufacturing techniques such as TIT, MRP, Group Technology, Computer Aided Process Planning etc., have allowed producers to benefit from the kind of economies associated with volume production, remaining at the same time batch producers, and retaining their product flexibility, capable of responding to particular customer needs. The application of AMT has given the opportunity to producers to combine flexibility and automation with specialist high quality products (Tippett, 1989). The mutual and dialectic interrelation of objectives, technology and organization is the core of Norwegian systematic manufacturing strategy and holds the key to its success. A new generation of smart industrial robots can produce more quickly, more flexibly and with greater precision. Such digitization of manufacturing well-suited a small, open economy with high wage costs and high levels of digital competence like Norway. Norway produces goods with higher knowledge content, and production is increasingly automated and flexible. This is a pre-requisite of being able to produce cost effectively and respond quickly to market changes. The requirements in terms of competencies and expertise of those working within manufacturing change. There is an increased need for staff with high levels of digital competence that crucially can benefit from the modern manufacturing technology. The government of Norway points to the need for proactive use of manufacturing technology and the importance this has for productivity and the ability to compete. Norway promotes the development of its manufacturing sector through up-to-date in technological development and are continually on the lookout for new knowledge that in turn provide a better knowledge base for a policy for future advances in its manufacturing industries. Norway strengthens its manufacturing sector by stimulating greater cooperation between research, manufacturing and government authorities to increase the nation's expertise in advanced manufacturing, make companies more competitive and create the best possible conditions for growth for new and smaller businesses as well. Knowledge transfer and exchange of experience between manufacturing companies which use advanced manufacturing to differing degrees and come from different industry sectors are significantly important. It is equally important for manufacturing to communicate its identified knowledge gaps to research centres and for the latter to disseminate the results of their research to the former. The government of Norway aids to boost the digital competence of manufacturing workers to be able to keep abreast of the most advanced manufacturing technologies. This ensures that industrial workers have the necessary expertise for which the boost in competence is directed at the education system and industrial workers currently in work, in equal measure. Educational and training establishments are made to be able to offer training in advanced robots and advanced digital control systems, as well as ways in which digital resources can create new business models. This kind of boost stimulates more individuals to want to work in design, product development and manufacturing. Increasing automation changes the type of expertise needed within manufacturing. There is a greater demand for people who can program, monitor and control the new machines. The need for operators of the traditional types of machine used in production declines. Instead of standing in the production hall handling and monitoring the machine itself, staff will be in a control room monitoring computers which keep the production process running properly. The government's well planned research strategy with an up-to-date knowledge base for developing future manufacturing that involves a number of things, including having the necessary knowledge about new technology and new types of manufacturing and value chains. Norwegian companies have to further streamline their own production processes to retain their competitive edge. Industrial robots do not eliminate people from production processes but they alter staffing needs and the type of expertise demanded and has an impact on the cost structure of the processes. The furniture industry in Norway has a high number of robots, and Norwegian companies also use robots for the production of equipment for the oil and gas sector and agriculture, as well as automotive and aircraft components and water heaters. Many of these have highly advanced production processes.

5.6 Results

These case studies identify conditions under which industries developed that played a significant role in the development process, which in turn enable us to understand the catch-up process and the building of local technological capacity in Brunei Darussalam. Two essential factors are discovered that are fundamentally crucial in developing technology-based industry; (i.) the concept of human capital recognizes that not all labour is equal and that the quality of employees can be improved by investing in them, and (ii.) education, experience and abilities of an employee have an economic impact on employers. Specific ability of an entity or resource is measured in quantity and level of quality over an extended period. In manufacturing terms, it refers to the highest sustainable output rate that can be achieved with current resources, maintenance strategies, product specifications, technical expertise, etc. These are literally translated as the human capital and technological capacity that promote the hi-tech industrial sector for which through such case studies provide valuable lessons for Brunei Darussalam to review its current industrial strategies in specified hi-tech areas. From the case studies, it was observed that basic characteristics of a nation including its natural resources and GDP, as well as industrial policies are weighed carefully. Others include the effectiveness of the country's legal system, the strength of its institutions and its political and economic stability. Government industrial policies that attract overall investment including policies on the repatriation of profits, taxes, monetary policy, environmental standards, labour laws and trade agreements all influence investment decisions. Government roles in creating the enabling the environment for investment are all factors that highly influence technology-based industry's success rate.

5.6.1 Lessons learned from Electronic Industry in Thailand

Thailand adapted its policies to align with the rapidly changing trends in the global economy. First, realizing that its domestic market was rather small to support industrialization, Thailand shifted from an import-substitution to an export-oriented development strategy. The government of Thailand has designed incentive schemes to channel investments into sectors of importance, such as electronics. Proactive government policies in Thailand have played a pivotal role in creating an enabling environment for the development of the electronics industry that has useful indicators to improve Brunei's industrial policies. The electronics industry in Thailand has acquired most of its technology through foreign direct investment (FDI) and trade. The foreign direct investment and trade have played a key role in building up the electronics industry by facilitating inflows of capital and technology and providing access to international markets. The success in Thailand's electronics industry are primarily influenced by factors including its competitive workforce, access to markets, excellent logistic system and development of electronics clusters. The Thai government's continued commitment in supporting Thailand's electronics industry is apparent in its continued investments in research programs designed to spur technological enhancements. The success story of Thailand is parallel to Brunei's aspiration in developing its silica sand into a hi-tech sustainable industry. The occurrence of silica sand in Brunei Darussalam can be seen as a pull factor in the technology of making the silicon chip and other semiconductor materials for the manufacturing of electronics products for which Brunei Darussalam can gain benefit from the Thailand experience through collaborative effort and industrial cooperation that provides each party with a long-term strategic advantage.

5.6.2 Lessons learned from Hi-Tech Agriculture in Peru

Peru's main advantages are its (i.) investor-friendly business environment and policy framework, (ii.) free or preferential trade agreements with major importers, such as the United States, the European Union (EU) and China, (iii.) relatively cheap labour and (iv.) good climate. Peru's agricultural export industry benefits from a combination of factors that have supported its rapid growth. New constitution and new laws introduced in the early 1990's, encouraged international investment in Peru as well as Peruvian engagement in international trade. Peru's export industry benefits from a business climate that welcomes foreign investors and encourages trade. Free trade agreements with all major trading partners, such as the United States, the European Union and China provide an invaluable stimulus to the export industry. The agricultural sector continues to be very labour intensive and Peru has been fortunate to have had access to abundant and relatively cheap farm labour that are highly skilled and knowledgeable. Lastly, Peru's climate is very well suited for the production of a range of fruits and vegetables. The success in Peru's Agri-tech is a lesson that is useful to stimulate Brunei Darussalam's direction from being highly dependent on hydrocarbon to high value agricultural plants, for example developing its Agar wood industry on large scale driven by hi-tech agricultural activities.

5.6.3 Lessons learned from Advance Manufacturing Technology in Norway

The development of new manufacturing technology, changes in demand and a new understanding of where and how manufacturing can and should be undertaken dictates the terms governing the manufacturing of the future. It alters the balance of international competition. It is therefore important to closely follow the development of this technology, understand the forces that drive it in the future and what importance it may have for the manufacturing sector and industrial policy. Like Norway, Brunei Darussalam has large ownership positions in key industrial sectors. The development of advance manufacturing technology in Norway is attractive to Brunei Darussalam as both countries mainly rely on hydrocarbon as the economical backbone but Norway successfully invested its financial reserve produced by exploitation of natural resources into the hi-tech industrial sector. Much of Norway's success is an imperative lesson to the development of hi-tech industries in Brunei Darussalam. This story of success in Norway's hi-tech industrial sector is explained by its abundant natural resources and stable macroeconomic policies, strong public institutions, remarkably high productivity and labor utilization and social stability. The productivity level in Norway's hi-tech industrial success is influenced by human capital, technology, work culture and norms, incentive systems, social structure and organization. All these lessons provide better input to develop Brunei's technology-based industry.

5.7 Conclusion

In conclusion, experiences from Thailand, Peru and Norway suggest that; firstly, the government of Thailand has launched proactive investment policies and measures, which have attracted investments from many multi-national companies. Investment promotion, development of science and technology capabilities and implementation of measures supporting the development of the electronics industry have been important components in Thailand's development strategy. The development of the hi-tech agricultural sector in Peru is a good example to learn from. High-value agricultural production for export using hi-tech industrial production focuses on innovation, skilled labor and local conditions. The Norwegian economy's strong competitiveness is built on openness and transparency with policies that support dynamic trade and investment. Norway promotes the development of its manufacturing sector through advanced technological development.

CHAPTER 6:

GENERAL CONCLUSION AND RECOMMENDATIONS

6.1 General conclusion

Outcomes from this research study are significantly important to Brunei's industrial development that in turn confers an immense contribution to the formulation of an integrated, thorough and comprehensive industrial policy for Brunei Darussalam by looking at other countries' experiences through SWOT-Analysis and Case-studies. This study concluded that the technology transfer environment and practices in Brunei Darussalam are weak and ineffective in advancing the search for sustainable development in its industrial sectors to fully promote the technology-based industry incentives. It is evidentially proved by Brunei's failure to attract foreign direct investment which is the primary mode for the transfer of technology to occur. Brunei Darussalam realizes that the advancement of technology is important in order to compete with other nations and is the primary means of ensuring a sustainable economic future. The government of Brunei Darussalam is fully aware that a resource-based economy is not sustainable and it must diversify its industrial activities to not depend solely on its hydrocarbon reserves. In reviewing of Brunei's industrial plan, it is proposed that the government should prioritize future actions on developing competitiveness in the technologically sophisticated and higher added-value industries that are becoming increasingly important in world trade. The study recommends the need to establish transparent, broad and effective enabling policies; and priorities to facilitate sustainable development, focusing especially on technology, science and innovation; and human and R & D capacities. The science system, essentially public research laboratories and institutes of higher education, carries out key functions in promoting technology education. The government has to implement new advance technology incentives that focus in the area of research and development. Case studies performed suggest ways for successful transfer of technology that Brunei Darussalam can take advantage off from experiences of other countries like Norway, Peru and Thailand. It is undeniable that the main modes of acquiring foreign technology are direct foreign investment that includes capital, technology, management, and access to foreign markets; licensing foreign technology through explicit contracts and imports of capital goods that embody technology. The study suggests that technological capability is essentially embodied in people, not in machinery. It is understood that in the process of acquiring, using and diffusing, adapting and developing technology, the most important input is the technical human capital base, which is able to assess and decide on technology matters. This needs a formal education system that lays the necessary foundations at higher levels. The level of skill gained through the educational system must be parallel and relevant to the local technological needs. Technically qualified people are necessary to understand, assess, select, assimilate, diffuse, adapt, improve and develop technology. Technical human capital can be developed through formal and informal training as well as through practical experience. Thus, both the formal educational system, as well as informal on-the-job training are important elements of a technological strategy and are the foundations for the rest of the structure. The management of human resource is most critical, as the quality of the product comes from the quality of people for it has to be well structured into the Brunei's human development strategy. Government policies need more stress on upgrading the human capital through promoting access to a range of skills and the capacity to learn; enhancing the knowledge distribution power of the economy through collaborative networks and the diffusion of technology; and providing the enabling conditions for organizational change to maximize the benefits of technology for productivity. A strategy to increase technological capabilities can only be understood as part of a broader industrial strategy aimed at strengthening Brunei's industrial competitiveness. This draws attention to the important role of government policy at the level of macro-management and at the level of structural reform in the industrial incentive regime. The development of technological capability also requires time and planning because it involves investment in human and institutional capital. Technology policy in Brunei Darussalam needs to be assessed constantly to measure the country's ability to acquire foreign technology, diffuse and use technology, improve and develop technology, and develop the technical human capital base that makes all the above possible. It is essential that Brunei Darussalam develop a coherent and well-articulated strategy to improve the nation's technological level that involves planning, coordination, and strong attention to implementation. The science, technology and industry policies need to be formulated to maximize the performance and well-being in realizing Brunei Darussalam's aspiration towards a "Technology-Based Economy". Such aspiration must reflect Brunei's drive towards growth in high-technology investments, high-technology industries, more highly-skilled labour and associated productivity gains. Government policies relating to science and technology, industry and education, need a new emphasis towards technology-based industrial requirements. This research also suggests that Case-studies have offered a thorough insight of the nature underlying industrial advancements in other countries and proved that experiences from those countries are very essential indicator for the industrial development in a developing country like Brunei Darussalam to advance its industrial sectors. Creating more effective and evidence-based industrial policies that do not just rely on developing and disseminating the evidence but also on building knowledge of the ways in which industrial innovations can be embedded into ongoing strategies. Finally, such study contributes to an immutable formula for successful implementation of industrial strategies to be the primary determinant of industrial success in Brunei Darussalam. Many studies in the past resulted in a poor implementation of the government's industrial policies. Future research should focus on in-depth case studies of specific industrial clusters as well as deepening the understanding of thematic measures of sustainability in Brunei's industrial context. The term "Dutch Disease" must be examined as it is directly related to Brunei's present economic situation.

6.2 Key Recommendations

I. The government needs to focus on three main areas:

i. Review its Industrial Policies

There is a need for industrial policy reforms in Brunei Darussalam. Industrial transformation agendas should create policies that are clear, precise, transparent, comprehensive, environmentally friendly and geared towards increasing economic competitiveness. Such reforms in industrial policies must also comply with international standards and requirements. The government's ability to align industrial efforts with its resource-base and level of development can strengthen Brunei's industrial sectors. "Some argue that while manufacturing should be given special policy treatment, governments should not favour particular manufacturing industries (UNIDO, 2011). One way to do this is by improving the infrastructure that manufacturers require, eg. by promoting industrial clusters (UNIDO, 2009)".

ii. Research and Development

Research and development activities are key to innovation and change for which Brunei Darussalam has to focus on strengthening the nation's research capabilities. The output of which is an intangible asset that is labeled as the "knowledge stock". The government of Brunei Darussalam needs to encourage innovative activities through direct spending on education and training, patent protection, regulation and competition policy. The formation of a National Scientific Laboratory and National Technology Research Hub can significantly promote R & D activities in science and technology related disciplines, they should specifically focus on the technological innovation as a new strategic economic growth strategy to drive Brunei Darussalam as a research intensive, innovative and entrepreneurial economy that creates high value jobs and prosperity for the nation.

iii. Development on Human Capital

The human capital growth is believed by economists to be important for economic growth. The government of Brunei Darussalam needs to strengthen its human capital development with an emphasis on Science and Technology Education, and a Technical training focus on targeted industries to promote job creation and better anticipation of, and investments in, the skills needed to promote industry's competitiveness. "It is widely believed that educational systems need to provide the right type and the right level of human capital investments for the economy in order to prosper (Schleicher, 2006)". Knowledge as a productive factor is contained in human capital, the economic factor. The development of human capital and R & D are interrelated. "Nelson and Phelps (2003) specify human capital as effective labour that is the weighted sum of the number of workers". The human capital expressed in education can be considered as an investment. "Scott R. Sweetland (as cited in Krueger & Lindahl, 2001) considers that human capital suggests that individuals and society derive economic benefits from investments in people". Educational attainment has an element of investment in future benefits that differentiate it from consumption consistently emerges as the prime human capital investment.

II. Key actions that will foster technology transfer in Brunei Darussalam:

i. Establish an analytic framework to identify opportunities for economical diversities and get the government to commit to this analytical approach
ii. Evaluation and strengthening of policies that influence the enabling environment
iii. Collaborative strategic partnerships with industry, relevant government agencies and other stakeholders
iv. Protection of intellectual property rights and legal contracts
v. Compliance with global standards and requirements, and international environmental policy
vi. Political support for programmes and institutions that foster technology transfer
vii. Funding incentives for industries that posses the potential to make contributions to technology transfer; ie. three potential areas are identified including semiconductor industry, Agri-tech industry and advanced manufacturing technology sector
viii. Identify and deliver the skills and resources necessary for an effective technology transfer strategy
ix. Ensuring that technology transfer initiatives are compatible with Brunei's sustainable development agendas
x. Measure and evaluate key performance indicators of technology transfer

6.3 Future work on Industrialization Strategies

Industrialization is vital for the development of Brunei Darussalam as it creates new job opportunities leading to greater potentialities and prosperity that consequently brings in a considerable rise in the standard of living for the population. It is understood that the economic environment created for industry by political action can be of the utmost importance in facilitating and shaping Brunei's economic spectrum as in its move towards diversifying its advanced-industrial sectors. The financial reserves from its hydrocarbon income can greatly enhance the process of rapid industrialization in Brunei Darussalam, which must by driven by a number of strategic forces that need to be well defined. It is essential to closely examine the principal strategic factors promoting growth; factors which may not be sufficient in themselves to produce successful industrialization, but factors which it would be very difficult to do without if the progress to a fully industrial economy is to be achieved in Brunei Darussalam. One sector that Brunei Darussalam needs to venture into in the near-term future is the Medical Technology Industry. The exploration in the field of "Advanced Medical Devices" can open up doors for other high-technology industries, such as microelectronics and biotechnology. The medical device industry relies upon microelectronics, telecommunications, instrumentation, biotechnology and software development. The future growth of this sector is positive as this industry is fueled by innovation and the ongoing quest for better ways of treating or diagnosing medical problems. Future work must investigate the potential of medical technologies, to understand whether Brunei Darussalam can derive benefit from it. The future work must also construct a plan for growth in the Brunei Darussalam industrial sector based on the studies to be carried out.

References

(CIA), C. I. A. World Fact Book: Brunei Darussalam. Retrieved March 2012, from https://www.cia.gov/library/publications/the-world-factbook/geos/bx.html

(FAO), F. a. A. O. o. t. U. N. (2016). Report on Brunei.

(IFC), I. F. C. Development Impact. Retrieved 4th November, 2011, from http://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/Development+Impact

Acher , J. (2007). UPDATE 1-Statistics Norway raises '07 GDP outlook, cuts '08. Retrieved 2nd March, 2009, from http://uk.reuters.com/article/norway-economy-forecasts-idUKL0674675920070906

Affairs, U. S. D. o. S. B. o. E. A. a. P. (2012). Background Note: Brunei Darussalam.

Agency, C. I. Country Comparison: Natural gas - production. The World Fact book. Retrieved 3rd March, 2016, from https://www.cia.gov/contact-cia/index.html

Allyn & Bacon, B. R. C. B. S. K. (2006). Qualitative research in education: An introduction to theory and methods (5 ed.): Pearson.

B.Beyers, W. (1997). The Economic Impact of Technology-Based Industries in Washington State.

Bank, W. (2011). Brunei Population Statistics: World Bank Report. Washington DC, USA.

Bank, W. (2014). Peru, World Bank Report.

Beñat Bilbao-Osorio, S. D., and Bruno Lanvin. (2013). The Global Information Technology Report:Growth and Jobs in a Hyperconnected World.

Benry, R. L. (1968). Technology: Alchemist of Route 128. Boston's 'Golden Semicircle, 139.

Bikash Barua , M. M. O. I. (2008). Key Success Factors for Implementation of Advanced Manufacturing Technologies (AMTs)-Case Study Conducted on Selected Pharmaceutical Companies in Bangladesh. International Journal of Pharmaceutical and Life Sciences, 2(1).

Bjørnland, H. C. (1998). The economic effects of North Sea Oil on the manufacturing sector. Scottish Journal of Political Economy, 45(5).

Broad, S. (1995)). Agar wood harvesting in Vietnam (pp. 15-96).

C., S. (1991). Technology upgrading in Thailand: A strategic perspective (pp. 3-10).

Campbell Robert, P. E. B. I. (2012). Academic and Professional Publishing (1 ed.): Chandos Publishing.

Carnoy, M. (2002). Is Latin American Education Preparing Its Workforce for 21st Century Economies? Washington , D.C.

Centre, I. E. T. (2003). Technology Transfer: The Seven "C"s for the Successful Transfer and Uptake of Environmentally Sound Technologies. Osaka , Japan.

Change, F. C. o. C. (1998). Barriers and Opportunities Related to the Transfer of Technology.

Chattedi, M. (1990). Technology Transfer in the Developing Countries. London: The Macmillan Press Ltd.

CIA. Purchasing Power Parity(GDP), . Retrieved 4 January 2015, from www.cia.gov

Clulow, V., Gerstman, J. , Barry, C. . (2003). The resource-based view and sustainable competitive advantage: the case of a financial services firm. Journal of European Industrial Training, 27(5), 220-232.

Department, V. B. E. D. Retrieved 1st June, 2010, from https://www.yesvirginiabeach.com/Pages/index.aspx

Diaconnu, M., Andrei,P. (2014). Technological Innovation: Concept, Process, Typology and Implications in the Economy. Theoretical and Applied Economics, 18(10), 127-144.

Edina Karabegovic , I. K. (2012). Industrial Robot Application Trend in World's Metal Industry.

Eguren, F. (2006). La Reforma Agraria en el Perú. Rome , Italy: Centro Peruano de Estudios Sociales.

Einar Hope , P. M. (1998). Competition and Trade Policies, Coherence or Conflict? : ROUTLEDGE STUDIES IN THE MODERN WORLD ECONOMY

Esfahani, S. (2010). Solvent Refining of Metallurgical Grade Silicon Using Iron. University of Toronto.

Esteves, J. (2003). Using a Multi-method Approach to Research Enterprise Systems Implementations. Academic Conferences Ltd, 2(2), 95-108.

F., A. L. (2003). Technological Development in Industry: A Business-Economic Survey and Analysis (2 ed.): ISR Publications.

Florin, P. C., S. (2015). Limits of SWOT Analysis and their impact on decisions in early warning systems. University Politehnica of Bucharest, Romania.

FORBES. (2009). China And Peru Sign Free Trade Agreement. Retrieved 3rd May, 2011, from http://www.forbes.com/2009/05/08/peru-china-fta-business-oxford-analytica.html

FORBES. (2012). Forbes ranks Brunei 5th richest nation. Retrieved 1st March, 2013, from http://www.forbes.com/pictures/egim45egde/5-brunei/#4aebb9fb7dba

Forum, W. E. (2016). The Fourth Industrial Revolution: what it means, how to respond.

Frankelius, P. (2009). Questioning two myths in innovation literature. Journal of High Technology Management Research, 20(1), 40–51.

Fund, I. M. Brunei Darussalam. Retrieved 10th April, 2012, from http://www.imf.org/external/country/BRN/index.htm

Gail Brooks, A. H. D. H. (2014). A SWOT Analysis Of Competitive Knowledge From Social Media For A Small Start-Up Business. Review of Business Information Systems,, 18(1).

George Tesar, S. G., Steven W. Anderson , Tom Bramorski. (2008). Strategic Technology Management: Building Bridges between Sciences, Engineering and Business Management (2 ed.): World Scientific Publishing.

Glaser, B. (1992). Basics of Grounded Theory Analysis: Emergence vs. Forcing, Mill Valley: Sociology Press.

Gomiero T., P. D. a. P., M. G. (2011). Environmental Impact of Different Agricultural Management Practices: Conventional Vs. Organic Agriculture. Critical Reviews in Plant Sciences, 30,(1-2), 95-124.

Greenfield, B. (2012). The World's Richest Countries

Hannah, T. (2007). Best practices to enhance the transportation land use connection in the rural United States.

Heidenheimer, A. J., Heclo, H. & Adams C.T. (1983). Comparative Public Policy: The Politics of Social Choice in Europe and America (2 ed.): New York: St. Martin Press.

Hodkinson, P. H. H. (2001). The Strengths and Limitations of Case Study Research.

IIPA. (2004). Thailand: International Intellectual Property Alliance 2004.

Institute, I. Physical Properties of Silicon. New Semiconductor Materials. Characteristics and Properties. Retrieved 2nd February, 2008, from http://www.ioffe.ru/SVA/NSM/Semicond/Si/

Institute, W. B. (2004). Benchmarking Countries in The Knowledge Economy: Presentation of the Knowledge Assessment Methodology (KAM) (pp. 4).

INTERNATIONAL, U. P. (2013). Norway top country in human well-being. Retrieved 2nd December, 2014, from http://www.upi.com/Top_News/World-News/2013/03/15/Norway-top-country-in-human-well-being/UPI-38211363358148/

J., E. (1989). Transfer of Technology. Asian-Pacific Economic Literature, 3, 337.

Kaplan, B., Duchon, D. (1988). Combining Qualitative and Quantitative Methods in Information Systems Research: A Case Study (pp. 571-586).

Khunkitti, S. (2001). Technology and development policy in poverty reduction: The case of Thailand. Paper presented at the Technology and Poverty Reduction in Asia and the Pacific, 7th International Forum on Asian Perspectives, Paris.

Lekhanya, L. M. (2014). The Significance of Emerging Technologies in Promoting Internationalization of Rural SMEs in South Africa. Mediterranean Journal of Social Sciences, 5(20).

Limited, N. S. P. (2016). Report on Brunei's agricultural sector.

Luis Abad, N. A., Kenichi Kitamura, Ramona Lohan and Alex Simalabwi. (2015). The Malaysian Semiconductor Cluster. Microeconomics of Competitiveness.

M. & E, G.-S. (2015). Perspectives on Innovation and Technology Transfer. Paper presented at the Proceedings - Social and Behavioral Sciences, Dubickis.

Mansfield, A. G. E. (2012). Finance and Security in East Asia: The Nexus of Economics, Security and International Relations in East Asia: Stanford University Press.

Maryville, S. (1992). Entrepreneurship in the Business Curriculum. Journal of Education for Business, 68(1), 27-31.

Mason Carpenter , S. P. D. (International Business: Opportunities and Challenges in a Flattening World, v. 1.0

McKinsey. (2002). Thailand: Prosperity through Productivity.

Merriam-Webster.com. Definition of Innovation Retrieved March, 2016, from http://www.merriam-webster.com/dictionary/innovation

Michael E., P., Chacarbaghi , Lynch. (1999). Competitive Advantage: Creating and Sustaining Superior Performance: Free Press.

Ministry of Agriculture , P. (1998). Primer Censo Nacional de Productores de Asparago. Lima.

Ministry of Development, B. D. (2012). Status of Hazardous Waste Management in Brunei Darussalam.

Ministry of Education , B. D. (2012). Ministry of Education Reports. Berakas.

Naef & Regula, M. (2011). The volatile and semi-volatile constituents of Agar wood, the infected heartwood of Aquilaria species: a review. Flavor and Fragrance Journal, 26(2), 73-87.

National Science and Technology Development Agency, a. M. o. S. T. a. E., Bangkok , Thailand. (2002). National ICT Master Plan. National Electronics and Computer Technology Center.

Nations, F. a. A. O. o. t. U. (2009). FAOSTAT database. Rome.

Nations, U. (2009). Human Development Reports. New York, USA.

Organization, U. N. I. D. (2015). The Role of Technology and Innovation in Inclusive and Sustainable Industrial Development Industrial Development Report 2016. Vienna.

Organization, W. B. from http://www.worldbank.org/

P. Brimble , J. S. (1999). Mergers and acquisitions in Thailand: The changing face of foreign direct investment. Paper presented at the United Nations Conference on Trade and Development (UNCTAD).

Pakirh , M. (2001). Knowledge Management Framework for High-Tech Research and Development. Engineering Management Journal, 13(3), 27.

Penny, R. (1992). Understanding the Technology Transfer Process: VITA Distribution Service.

Pierre, L. R. a. J. (2005). Antecedents and Performance Outcomes of Advanced Manufacturing Systems Sophistication in SMEs. International Journal of Operations & Production Management, 25(6), 514-533.

Porter, M. E. (1985). Competitive Advantage: Free Press.

Press, U. o. H. (1998). Tigers Tamed: The End of the Asian Miracle. Hawaii, USA.

Prime Minister's Office, B. S. B., Brunei Darussalam. (2007). Public Policy in Brunei Report.

Prime Minister's Office, B. S. B. (2011). Brunei Economic Development Board Report.

Program, U. N. D. (2011). Human Development Reports.

Report, N. B. D. (2010). Annual National Accounts (pp. 8).

Representative, O. o. t. U. S. T. (2006). Peru Trade Promotion Agreement. Retrieved 3rd May, 2007, from https://ustr.gov/trade-agreements/free-trade-agreements/peru-tpa

Resources, F. I. f. G. a. N. (1988). Preliminary evaluation of silica sands in the coastal region of Negara Brunei Darussalam. Hannover, Germany.

Robert Ayres , S. M. (1981). The Impacts of Industrial Robots: Department of Engineering and Public Policy, The Robotics Institute.

Rothbauer, P. (2008). Triangulation: Sage Publications.

Science, O. (2009). Competing in the World Economy (Vol. Technology and Industry Scoreboard).

Sheehan, P. (2010). Beyond Industrialization, New Approaches to Development Strategy Based on the Service Sector: Palgrave Macmillan UK.

Shirley, B. M. (2014). The Asian Tigers from Independence to Industrialisation. http://www.e-ir.info/2014/10/16/the-asian-tigers-from-independence-to-industrialisation/

Sigurdson, J. (1990). Measuring the Dynamics of Technological Change: London: Pinter Publishers.

Sternberg , R. J. (2011). Cognitive Psychology: Wadsworth Publishing.

Survey, U. G. (2009). Mineral Commodity Summaries (pp. 146).

Survey, U. G. (2011). Mineral Commodity Summaries.

T, S. (2004). Research Project on Use and Analysis of Industrial Survey Data, .

Tellis, W. (1997). Application of a Case Study Methodology. The Qualitative Report, 3(3).

Thomas Dietz, U. S., Marc Barho, Susanne Oberer-Treitz, Manuel Drust, Rebecca Hollmann & Martin Hagele. (2013). Programming System for Efficient Use of Industrial Robots for Deburring in SME Environments. Germany.

Times, B. (2015). Brunei strives to improve its labour market. http://bt.com.bn/news-national/2015/12/28/brunei-strives-improve-its-labour-market

U.S. Congress, O. o. T. A. (1984). Technology, innovation and regional economic development: encouraging high technology development. Washington D.C.

Varga, A. (1998). University research and regional innovation: A spatial econometric analysis of academic technology transfers. Boston: Kluwer Academic Publishers.

Warf, F. P., Stutz, B. (2007). The World Economy: Resources, Location, Trade and Development Pearson.

Willis, B. (2014). The Advantages and Limitations of Single Case Study Analysis.

BIBLIOGRAPHIES:

B. Beiske, 200. 7Research Methods: Uses and Limitations of questionnaires, interviews and case studies, GRIN Verlag.

PM. Gulati, 2009. Research Management: Fundamental and Applied Research, Global India Publications.

R. Pelissier, (2008). Business Research Made Easy, Juta & Co.

R. Snieder & K. Larner, 2009. The Art of Being a Scientist: A Guide for Graduate Students and their Mentors, Cambridge University Press.

T. Bonoma,, (1985). Case Research in Marketing: Opportunities, Problems and a Process, Journal of Marketing Research, 2(2), pp.199-208.

H. Klein & M. Myers, (1999). A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems, MIS Quarterly, 23(1), pp.67-94.

B. Kaplan, D. Duchon, (1988). Combining Qualitative and Quantitative Methods in Information Systems Research: A Case Study, MIS Quarterly, December 1988, pp.571-586.

B. Glaser, (1992). Basics of Grounded Theory Analysis: Emergence vs. Forcing, Mill Valley, CA: Sociology Press.

L. Bratthall, M. Jorgensen, (2002). Can You Trust a Single Data Source Exploratory Software Engineering Case Study?, Empirical Software Engineering 7, pp.9-26.

A. Hunter, J. Brewer J, (2003). Multimethod Research in sociology, Tashakkori and Teddlie (2003), pp.577-594,

D. Erlandson, E. Harris, B. Skipper, & S. Allen, (1993). Doing naturalistic enquiry: A guide to methods, Newbury Park, CA: Sage,
G. Gibbs, (2002). Qualitative analysis with Nvivo, Open University Press, Buckingham.

J. Maxwell, (1996). Qualitative Research: an Interactive Approach, Thousand Oaks, CA: Sage.

J. Mingers, J. Brocklesby, (1997). Multimethodology: Towards a Framework for mixing Methodologies, Omega 25(5), pp.489-509.

K.T. Alexandiris, (2006)Exploring Complex Dynamics in Multi Agent-Based Intelligent Systems, Pro Quest,

W. Goddard, & S. Melville, (2004)Research Methodology: An Introduction 2nd edition, Blackwell Publishing,

Allyn & Bacon,W.L. Neuman, (2003). Social Research Methods: Qualitative and Quantitative Approaches.

Paul Brewerton & Lynne Millward, 2001. Organizational Research Methods, A Guide for Students and Researchers.

A.J. Allan & L.J. Randy, 2005. Writing the Winning Thesis or Dissertation. A Step-by-Step Guide, Corwin Press, California.

R.B. Brown, 2006. Doing Your Dissertation in Business and Management: The Reality of Research and Writing, Sage Publications.

L. Cohen, L. Manion, K. Morrison, & R.B. Morrison, 2007. Research Methods in Education, Routledge.

O'Leary Z., 2004. The essential guide to doing research, Sage.

J. Bell, 2010. Doing Your Research Project: A Guide for First Time Researchers in Education, Health and Social Science, Fifth Edition.

R.B. Brown, 2006. Doing Your Dissertation in Business and Management: The Reality of Research and Writing, Sage Publications.

J.J. Lambin, 2000. Market-Driven Management. Strategic & Operational Marketing, Palgrave.

N.K. Denzin, Y.S. Lincoln, (eds.), 2000. Handbook of Qualitative Research. London: Sage Publications.

C. Pope, N. Mays, 2000. Qualitative Research in Health Care. London: BMJ Books.

P. Nkwi, I. Nyamongo, G. Ryan, Field, 2001. Research into Social Issues: Methodological Guidelines. Washington, DC: UNESCO.

K. Baker, (2007). Are international test scores worth anything? Phi Delta Kappan, 89(2), pp.101-104.

J. Best, & J. Kahn, (2006). Research in Education, New York: Pearson.

J.H. Goldthrope,(1997). Current Issues in Comparative Macrosociology: a debate on methodological issues. In Mjø set L., F. Engelsta., G. Brochmann, R. Kalleberg, & A. Leira, (eds). Comparative Social Research (Vol.16): Methodological Issues in Comparative Social Science. Greenwich, CT: JAI Press, pp.1-26.

R.L. Sandhusen, 2000. Marketing, Barrons.

M. Saunders, P. Lewis, A. Thornhill, 2007. Research Methods for Business Students, 4th edition, Prentice Hall,

K. Singh, 2007. Quantitative Social Research Methods, SAGE Publications.

N.K. Malhotra, D.F. Birks, 2000. Marketing Research. An Applied Approach, European Edition, Prentice Hall.

L. Cohen, L. Manion, K. Morrison, & R.B. Morrison, (2007). Research methods in education, Routledge.

V. Oliver, 2010. Smart Answers to Tough Business Etiquette Questions, Skyhorse Publishing, New York USA.

R. Nargundkar, 2008. Marketing Research: Text and Cases, Tata McGraw-Hill Educational.

J.P. Neenlankavil, 2007. International Business Research, ME Sharpe.

E.R. Babbie, (2010). The Practice of Social Research, Cengage Learning.

J. Wilson, (2010). Essentials of Business Research: A Guide to Doing Your Research Project, SAGE Publications.

A. Bryman, & E. Bell, (2007) Business Research Methods, 2nd Edition, Oxford University Press.

A. Bryman, & E. Bel, (2011). Business Research Methods, 3rd edition, Oxford University Press.

J. Collis, & R. Hussey, (2003). Business Research. A Practical Guide for Undergraduate and Graduate Students, 2nd Edition, Palgrave Macmillan.

M. Saunders, P. Lewis, A. Thornhill, 2007. Research Methods for Business Students, 4th Edition, Prentice Hall.

D. Remenyi, A. Money, 2004. Research Supervision for Supervisors and their Students, Academic Conferences Ltd.

W. Barry, (2012). Is Modern American Education Promoting a Sane Society?: International Journal of Science, Vol.2, pp.69-81.

D. Burns, 2015. Navigating complexity in international development: Facilitating sustainable change at scale. Rugby: Practical Action.

M. Denscombe, 2004. The Good Research Guide for small-scale social research, 2nd Edition, Open University Press.

S.L. Jackson, 2011. Research Methods and Statistics: A Critical Approach, 4th Edition, Cengage Learning.

J.L. Thompson, & F. Martin, (2010). Strategic Management: Awareness & Change, Cengage Learning.

G.V.S. Sekhar., (2010). Business Policy and Strategic Management, I.K. International Pvt. Ltd.

P. Fiflied, (2012). Marketing Strategy, 3rd Edition, Routledge.

C.A. Rao, B.P. Rao & K. Rao, (2009). Strategic Management and Business Policy: Text and Cases, Excel Books.

Sally Wyatt, Flis Henwood, Nod Miller & Peter Senker, 2000. Technology & In/Equality, Questioning the Information Society.

Maxine Berg & Kristine Bruland, 1998. Technological Revolutions in Europe, Historical Perspectives.

J. Nigel, Smith, 2002. Engineering Project Management, 2nd Edition.

Gambardella Alfonso & Malerba Franco, 1999. The Organization of Economic Innovation in Europe.

A. Bergek, S. Jacobsson, B. Carlsson, S. Lindmark & A. Rickne, (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis, Research Policy 37.

R.A.A. Suurs, 2009. Motors of sustainable innovation. Towards a theory on the dynamics of technological innovation systems (Thesis), Utrecht University, Utrecht.

Sustainable Development is the New Economic Paradigm", BANURI, Tariq, Development 56:2, 2013

COHEN, Benjamin, 2012. Finance and Security in East Asia", The Nexus of Economics, Security and International Relations in East Asia, Eds. A. Goldstein & E. Mansfield, California, USA: Stanford University Press.

E.B. Grant, M.J. Gregory, 1997. Tacit knowledge, the life cycle and international manufacturing transfer. Technology Analysis and Strategic Management 9_2., pp.149–161.

J. Molas-Gallart, 1997. Which way to go? defense technology and the diversity of 'dual-use' technology transfer. Research Policy 26_3., pp.367–385.

Baskerville, Richard & Jan Pries-Heje, (2001). A multiple-theory analysis of a diffusion of information technology case', Information Systems Journal 11: 181-212.

M.J. Moon, & S. Bretschneider, 1997. Can state government actions affect innovation and its diffusion?: an extended communication model and empirical test. Technological Forecasting and Social Change 54_1., pp.57–77.

Breznitz Dan., (2005). Collaborative Public Space in a National Innovation System: A Case Study of the Israeli Military's Impact on the Software Industry', Industry and Innovation (12) 1: 31–64.

Caryannis, Elias & Eric Turner, (2006)Innovation Diffusion and Technology Acceptance: The Case of PKI Technology', Technovation 26: 847–855.

Castellacci, Fulvio, Stine Grodal, Sandro Mendonca & Mona Wibe, (2005). Advances and Challenges in Innovation Studies', Journal of Economic Issues 39 (1): 91-122, Assisted Technology Transfer to SMEs: Lessons from an Exemplary Case Department of Business Studies, University of Genoa, Via Vivaldi 2, I-16126 Genoa, Italy, Technovation (Impact Factor: 2.53). 01/2001.

The European Union's ICT Program in FP7", 713 EFP Consulting (European Framework Program Consulting Limited), Myer W Morron, Version 1.13, at para 14.1 714 Article 48(3) FP7 RfP; Article II.32.7 FP7 GA, August 2008

Puga Diego & Trefler, Daniel (2010) . Wake up and smell the ginseng: International trade and the rise of incremental innovation in low-wage countries", Journal of Development Economics, 91(1):64-76.

Sohn Eunhee (2014). The Impact of Local Industrial R & D on Academic Science: Evidence From the Agricultural Biotechnology Industry", Academy of Management Annual Meetings Best Paper Proceedings.

Xie Zhuan & Zhang X, 2015. The Patterns of Patents in China", China Economic Journal 8.2 pp.122-142.

Hale, Galina & Cheryl Long, 2011. Are there productivity spillovers from foreign direct investment in China?", Pacific Economic Review 16.2 pp.135-153.

Holmes, J. Thomas, R. Ellen,. Mc Grattan & Edward C. Prescott 2015. Quid pro quo: technology capital transfers for market access in China", Review of Economic Studies.

Draca, Mirko, (2013). Reagan's innovation dividend? Technological impacts of the 1980s US defense build-up".

Kantor, Shawn & Alexander Whalley 2014. Knowledge spillovers from research universities: evidence from endowment value shocks." Review of Economics and Statistics 96.1, pp.171-188.

Kay, Luciano, et al., 2014. Patent overlay mapping: Visualizing technological distance", Journal of the Association for Information Science and Technology 65.12, pp.2432-2443.
UNCTAD (United Nations Conference on Trade and Development), The Least Developed Countries Report; Knowledge, Technological Learning and Innovation for Development, United Nations, Geneva, (2007)

Atuahene-Gima, Kwaku & A. Ko, (2001). An Empirical Investigation of the Effect of Market Orientation and Entrepreneurship Orientation Alignment on Product Innovation, Organization Science, 12(1):54–74.

Bell, J. Simon, Whitwell, J. Gregory, Lukas & A. Bryan, (2002). Schools of Thought in Organizational Learning, Journal of the Academy of Marketing Science, 30(1):70–86.

Brown, Steve & Maylor Harvey, (2005). Strategic Resonant Firms, Mass Producers, Big Fish and Flat Liners: A Study of Policies, Practices and Performance in Innovation, Technovation 25(4):307–19.

Cefis Elena & Ciccarelli Matteo, (2005). Profit Differentials and Innovation, Economics of Innovation and New Technology, 14(1–2):43–61.

Chen, Guoguan, Liu, Chunghong & Tjosvold Dean (2005). Conflict Management for Effective Top Management Teams and Innovation in China, Journal of Management Studies, 42(2):277–300.

Hosseini, Hamid Khodadad, Azar, Adel Rostamy & Ali Asghar Anvary (2003). The Intervening Role of Innovative Climate: A Study of Middle Managers in Manufacturing Organizations in Iran, Public Organization Review, 3(2):151–70.

King, Adelaide Wilcox, Zeithaml & P. Carl,. (2003). Measuring Organizational Knowledge: A Conceptual and Methodological Framework, Strategic Management Journal, 24(8):763–72.

Larsen, Graeme Ballal & M. Tabarak, (2005). The Diffusion of Innovations within a UKCI Context: An Explanatory Framework, Construction Management and Economics, 23(1):81–91.

Kundu, K. Sumit,. & Katz, A. Jerome, (2003). Born-International SMEs: BI-Level Impacts of Resources and Intentions, Small Business Economics, 20(1):25–47.

Schlegelmilch, B. Bodo, Diamantopoulos, Adamantios & Kreuz Peter, (2003). Strategic Innovation: The Construct, Its Drivers and Its Strategic Outcomes, Journal of Strategic Marketing, 11(2):117–32.

G. Verona. & D. Ravasi, (2003). Unbundling Dynamic Capabilities: An Exploratory Study of Continuous Product Innovation, Industrial and Corporate Change, 12(3):577–606.

Zhou, Kevin Zheng, Chi, Kin Yim & Tse, K. David, (2005). The Effects of Strategic Orientations on Technology- and Market-Based Breakthrough Innovations, Journal of Marketing, 69(2):42–60.

N. Meade & T. Islam, (2006). Modelling and forecasting the diffusion of innovation—a 25-year review, Int. J. Forecast., 22 pp.599-545.

B. Jacobs, (2011). From Optimal Tax Theory to Applied Tax Policy: Lessons from the Netherlands for Norway", mimeo, Erasmus University Rotterdam.

B. Jacobs, & A.L. Bovenberg, (2010). Human Capital and Optimal Positive Taxation of Capital Income", International Tax and Public Finance, 17(5), pp.451-478.

M.R. Jacobsen, (2008). Norwegian Economic National Report", in: Yearbook for Nordic Tax Research 2008: Taxation of Capital and Wage Income; Towards Separated and or More Integrated Personal Systems, DJØF Publishing, Copenhagen.

Anonymous, and Then There Was One. (European Technology and Investment Research Center to takeover Eclipse Aviation Corp.), Very Light Jet Report, January 2009

J.D. Linton & S.T. Walsh 2008. A theory of innovation for process based innovations such as nanotechnology, Technol. Forecasting Soc. Change 75, pp.583–594.

B.R. Katzy & K. Crowston 2008. Competency rallying for technical innovation—the case of the Virtuelle Fabrik, Technovation 28 (10), pp.679–692.

J. Jin 7 M. von Zedtwitz, 2008. Technological capability development in China's mobile phone industry, Technovation 28 (6), pp.327–334.

L. Pereira & G.A. Plonski, 2009. Shedding light on technological development in Brazil, Technovation 29 (6–7), pp.451–464.

D. Cetindamar, R. Phaal & D. Probert, 2009. Understanding technology management as a dynamic capability: a framework for technology management activities, Technovation 29 (4), pp.237–246.

I. Joumard, M. Pisu, & D. Bloch, (2012). Less Income Inequality and More Growth – Are They Compatible? Part 3: Income Redistribution via Taxes and Transfers across OECD Countries", OECD Economics Department Working Paper, No. 926, Paris.

M. Kim & H. Kim, 2004. Innovation diffusion of telecommunications: General patterns, diffusion clusters and differences by technological attribute, Int. J. Innov., Manage., 8 (2) pp.223–241.

OECD (2011b), Global Forum on Transparency and Exchange of Information for Tax Purposes Peer Reviews: Norway 2011, OECD Publishing, Paris, 2011

T. Piketty, & E. Saez (2011). A Theory of Optimal Capital Taxation", mimeo, Paris School of Economics and University of California at Berkeley.

M. Bianchi, A. Cavaliere, D. Chiaroni, F. Frattini & V. Chiesa, 2011. Organisational modes for open innovation in the bio-pharmaceutical industry: an exploratory, Technovation, 31 (1) pp.22–33.

P. Ritala & P. Hurmelinna-Laukkanen, 2009. What's in it forme? Creating andappropriating value in innovation-related coopetition, Technovation, 29 (12), pp.819–828.

C. Musso, 2009. New learning from old plastics: the effects of value-chain-complexity on adoption time, Technovation, 29 (4), pp.299–312.

R.W. Rycroft, 2007. Does cooperation absorb complexity? Innovation networks and the speed and spread of complex technological innovation, Technol. Forecasting Soc., Change 74 (5), pp.565–578.

M. Golosov, & A. Tsyvinski (2006). Designing Optimal Disability Insurance: A Case for Asset Testing", Journal of Political Economy, 114(2), pp. 257-279.

R. Griffith, J.R. Hines & P.B. Sørensen, (2010). International Capital Taxation", Dimensions of Tax Design, Oxford University Press, Oxford.

W. Dolfsma & L. Leydesdorff, 2009. Lock-in and break-out from technological trajectories: modeling and policy implications, Technol. Forecasting Soc., Change 76 (7), pp.932–941.

The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business School Press, Boston, 1997

S. Dasgupta & A. Singh (2007). Manufacturing, Services and Premature Deindustrialization in Developing Countries: A Kaldorian Analysis'. In G. Mavrotas and A. Shorrocks (eds), Advancing Development: Core Themes in Global Economics. Basingstoke: Palgrave Macmillan for UNU-WIDER.

B. Eichengreen, Y. Rhee & Hui Tong (2007). China and the Exports of Other Asian Countries'. Review of World Economics, 143 (2): 201-07.

B. Naughton, (2006). The New Common Economic Program: China's 11th Five Year Plan and What It Means'. China Leadership Monitor, 16.

B. Naughton B., (2007). The Chinese Economy: Transitions and Growth. Cambridge, MA: MIT Press.

China Statistical Yearbook 2006. Beijing: National Bureau of Statistics China, NBSC (2006)

Statistical Communiqué on the 2006 National Economic and Social Development', NBSC, Beijing, February (2007)

R.D. Atkinson, & S. Andes (2008). The 2008 State New Economy Index. Washington, D.C., The Information Technology and Innovation Foundation.

R., Charuworn, A. & S. Kim (2008). State Technology and Science Index, Enduring Lessons for the Intangible Economy, Santa Monica, Milken Institute, DeVol.

Employment Security Department, Washington State (2009). Nonagricultural Wage and Salary Estimates, 2007 and Projected 2012 and 2017

Annual Retail Trade Survey 2007, Estimated Annual Gross Margins as a percentage of sales of U.S. Retail Firms, U.S. Census Bureau (2009)

2008 Annual Wholesale Trade Report, Table 5 Purchases and Gross Margins of U.S. Merchant Wholesalers, U.S. Census Bureau (2010)

Annual Report of Awards and Expenditures Related to Research, Training, fellowships, and other Sponsored Programs, 2009. Prepared by the Office of Sponsored Programs and Grant and Contract Accounting for the period July 1, 2008 through June 30, 2009, University of Washington, Seattle.

W. Beyers, (2008). The Economic Impact of Technology-Based Industries in Washington State. Seattle, Technology Alliance.

Sohn & Eunhee (2014). The Impact of Local Industrial R & D on Academic Science: Evidence From the Agricultural Biotechnology Industry", Academy of Management Annual Meetings Best Paper Proceedings.

Keller & Wolfgang, 2010. International trade, foreign direct investment, and technology spillovers", Handbook of the Economics of Innovation 2, pp.793-829.

Furman, L. Jerey, & J. Megan, Mac Garvie, 2007. Academic science and the birth of industrial research laboratories in the US pharmaceutical industry", Journal of Economic Behavior & Organization 63.4:756-776.

Quid pro quo: technology capital transfers for market access in China", Holmes, J. Thomas R. Ellen,Mc Grattan and Edward C. Prescott, Review of Economic Studies, 2015

Hu, G.Z. Albert Gary H. Jerson, and Qian Jinchang, 2005. R & D and technology transfer: firm-level evidence from Chinese industry", Review of Economics and Statistics 87.4:780-786.

Bloom, Nicholas, Mark Schankerman and John Van Reenen, 2013. Identifying technology spillovers and product market rivalry." Econometrica 81.4:1347-1393.

Arora, Ashish, Andrea Fosfuri and Alfonso Gambardella (2001). Markets for Technology: The Economics of Innovation and Corporate Strategy (Cambridge; MIT Press).

D'Este, Pablo, Frederick Guy and Simona Iammarino, (2012). Shaping the formation of university–industry research collaborations: what type of proximity does really matter?", Journal of Economic Geography.

Yusuf Shahid, (2007). From Creativity to Innovation, Policy Research Working Paper 4262, Development Research Group, World Bank, Washington D.C.

Nicholson, Michael (2002). Intellectual Property Rights and International Technology Transfer: The Impact of Industry Characteristics", U.S. Federal Trade Commission, manuscript.

J.L. Funk, (2004). Emerging Business Applications in the Japanese Mobile Internet, Japan Media Review.

M. Iansiti, & R. Levien, (2004). Strategy as Ecology, Harvard Business Review, 82, 3, pp.69-78.

P. Kale, & P. Puranam, (2004). Choosing Equity Stakes in Technology-Sourcing Relationships: An Integrative Framework. California Management Review, 46, 3, pp.77-99.

R.S. Kaplan, & D.P. Norton, (2004). Strategy Maps: Converting Intangible Assets Into Tangible Outcomes. United States of America: Harvard Business School, Publishing Corporation.

J. Koskinen, J. Takala, & J. Awali, (2013). Dynamic Business Model based on research in power electronics industry. Management and Production Engineering, Review. 4:4, pp.63–72.

O. Pekkarinen, M. Piironen, & R.T. Salminen, (2012). BOOT business model in industrial solution business, International Journal of Business Innovation and Research 6:6, pp. 653–673.

M.E. Porter, (2008). The Five Competitive Forces That Shape Strategy. If You Read Nothing Else on Strategy, Read Thesebest-Selling Articles, pp.25.

J. Takala, J. Koskinen, Y. Liu, M. Serif Tas, & M. Muhos, (2013). Validating knowledge and technology effects to operative sustainable competitive advantage. Management and Production Engineering Review 4:3, pp.45–54.

D.J. Teece, (2012). Dynamic Capabilities: Routines versus Entrepreneurial Action. Journal of Management Studies 49:8, pp.1395–1401.

D.J. Teece, (2010). Technological Innovation and the Theory of the Firm: The Role of Enterprise-Level Knowledge, Complementarities and (Dynamic) Capabilities.

D. Chatterjee, (2012). Innovativeness: a team knowledge and communication perspective', International Journal of Innovation and Learning, Vol.12, No.3, pp.229–246.

R. Wilden, S.P. Gudergan, B.B. Nielsen, & I. Lings, (2013). Dynamic capabilities and performance: Strategy, structure and environment. Long Range Planning.

P. Zheng,(2012). New strategic management business models for new technology-based firms. Proceedings – 2012 4th International Conference on Multimedia and Security, MINES 2012, pp.828.

Barba G. Navaretti, and A.J. Venables (2004, eds). Multinational firms in the world economy.

P. Egger, and M. Pfaffermayr, (2004). Foreign Direct Investment and European Integration in the 1990s. The World Economy 27 (1):99–110.

J.H. Mutti, (2004). Foreign Direct Investment and Tax Competition. Washington: Institute for International Economics.

J. Mutti,and H. Grubert, (2004). Empirical Asymmetries in Foreign Direct Investment and Taxation. Journal of International Economics 62 (2):337-358.

L. Resmini, (2000). The determinants of foreign direct investment in the CEECs. Economics of Transition 8 (3):665-689.

D.L. Swenson, (2004). Foreign Investment and the Mediation of Trade Flows. Review of International Economics 12 (4):609-629.

P. Walkenhorst, (2004). Economic Transition and the Sectoral Patterns of Foreign Direct Investment. Emerging Markets Finance and Trade 40 (2):5-26.

D. J. Bennett, and H. Zhao, (2004). International technology transfer: perceptions and reality of quality and reliability. Journal of Manufacturing Technology Management, 15 (5), pp.410-415.

A. Caldera, & O. Debande, (2010). Performance of Spanish universities in technology transfer: An empirical analysis, Research Policy 39 (2010) pp.1160–1173.

IETC, 2003: pp.114 Environmentally Sound Technologies for Sustainable Development. International Environmental Technology Centre (IETC), United Nations Environment Programme, Osaka, Japan.

Industrial Policy in Developing Countries: Overview and Lessons from Seven Country Cases. Discussion Paper 4/2011. Bonn: German Development Institute, 2011

R.E. Baldwin, 2011. Trade and Industrialization After Globalization's 2nd Unbundling: How Building and Joining a Supply Chain Are Different and Why It Matters, Working Paper 17716. Cambridge, MA: The National Bureau of Economic Research.

M. Chertow and J. Ehrenfeld, 2012. Organizing Self-Organizing Systems: Toward a Theory of Industrial Symbiosis, Journal of Industrial Ecology, 16(1), pp.13–27.

S. Chung, 2011. Innovation, Competitiveness and Growth: Korean Experiences. In: Annual World Bank Conference on Development Economics –Global 2010. Lessons from East Asia and the Global Financial Crisis, eds. Lin J.Y. and Pleskovic B., Washington, DC: The World Bank,

C. Dahlman, 2010. Innovation Strategies in Brazil, India and China: From Imitation to Deepening Technological Capability in the South. In: The Rise of Technological Power in the South, eds. Xiaolan Fu; and Luc Soete, London: Palgrave Macmillan.

Schwaag Serger S. and Remoe S, Luxembourg, 2012. International Cooperation in Science, Technology and Innovation: Strategies for a Changing World. Report of the Expert Group Established to Support the Further Development of an EU International STI Cooperation Strategy, eds.

J. Fagerber, and M. Srholec, 2008. National Innovation Systems, Capabilities and Economic Development. Research Policy, 37(9), pp.1417–1435.

J. Fagerberg, M. Srholec, and B. Verspagen, 2010. Innovation and Economic Development. In: Handbook of the Economics of Innovation, Volume 2, eds. Hall B. and Rosenberg N., Oxford: North-Holland.

Fu X., C. Pietrobelli, and L. Soete, 2011. The Role of Foreign Technology and Indigenous Innovation in the Emerging Economies: Technological Change and Catching-up, World Development, 39(7), pp.1204–1212.

Hirsch-Kreinsen H., 2008. Low-Technology": A Forgotten Sector in Innovation Policy. Journal of Technology Management and Innovation, 3(3), pp.11–20.

The Industrial challenge facing Africa in the Global Trading System, Discussion, Paper prepared by UNIDO for the 17th Conference of the African Ministers of Industry (CAMI),June 2006.

C. Ahya, and A. Xie, (2004). New tigers of Asia. India and China: a special economic analysis. Morgan Stanley.

Gillham Bill., (2001). Case Study Research Methods. London, New York: Continuum.

J. Bos, & E. Stam, (2011). Gazelles, industry growth and structural change", Paper presented at the RATIO workshop on high-growth firms, Stockholm.

Dosi G. P Llerena & M Sylos Labini (2006). The relationships between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'European Paradox'" Research Policy 35, 1450-1464.

B. Bozeman, J. Rogers, D. Roessner, H. Klein, J. Park, & J. Dietz, February 1999. Assessing impacts of basic research:Phase I. The Research Value Mapping Project. Final Report to the Office of Basic Energy Science. School of Public Policy, Atlanta, GA.

Managing Technological Change. An explanatory summary of the IPCC Working Group III Special Report "Methodological and Technological Issues in Technology Transfer. United Nations Environment Programme (UNEP), Division of Technology, Industry and Economics (DTIE), Paris, France, pp.20 UNEP, 2001

Laura and Helen Simpson (2011). Geographic proximity and firm –university innovation linkages: evidence from Great Britain." Journal of economic geography, Abramovsky.

Belenzon, Sharon and Mark Schankerman, 2013. Spreading the word: Geography, policy and knowledge spillovers." Review of Economics and Statistics 95.3: 884-903.

Bloom, Nicholas, Mark Schankerman and John Van Reenen, 2013. Identifying technology spillovers and product market rivalry." Econometrica 81.4 : 1347-1393.

D'Este, Pablo, Frederick Guy and Simona Iammarino, (2012). Shaping the formation of university–industry research collaborations: what type of proximity does really matter?." Journal of Economic Geography.

Kay, Luciano, et al., 2014. Patent overlay mapping: Visualizing technological distance." Journal of the Association for Information Science and Technology 65.12 : 2432-2443

I. Joumard I., M. Pisu and D. Bloch (2012). Less Income Inequality and More Growth – Are They Compatible? Part 3: Income Redistribution via Taxes and Transfers across OECD Countries", OECD Economics Department Working Paper, No. 926, Paris.

Sohn & Eunhee (2014). The Impact of Local Industrial R&D on Academic Science: Evidence From the Agricultural Biotechnology Industry." Academy of Management Annual Meetings Best Paper Proceedings.

Xie Zhuan and Zhang X., 2015. The Patterns of Patents in China", China Economic Journal 8.2 : 122-142.

APPENDICES

Appendix: 1

Table: (A1) Brunei Darussalam: Nominal GDP by Economic Activity, 2005–10
(In millions of Brunei dollars)

	2005	2006	2007	2008	2009	2010
Gross domestic product (GDP)	15,864.1	18,225.8	18,458.4	20,397.9	15,611.4	16,867.3
Oil and gas sector	10,540.4	12,491.0	12,332.9	14,300.0	9,417.0	10,461.8
Oil and gas mining	8,868.0	10,768.4	10,603.7	11,672.0	7,389.7	8,571.7
Manufacture of liquefied natural gas (LNG)	1,672.4	1,722.6	1,729.3	2,628.0	2,027.3	1,890.1
Non-oil and gas sector	5,323.4	5,734.7	6,125.5	6,097.9	6,194.3	6,405.5
Government	1,847.0	2,008.5	2,239.4	2,152.2	2189.73	2,312.5
Private sector	3,476.4	3,726.2	3,886.1	3,945.7	4,004.6	4,093.0
Non-oil and gas sector	5,323.4	5,734.7	6,125.5	6,097.9	6,194.3	6,405.5
Vegetables, fruits and other agriculture	23.6	20.5	24.6	29.9	29.31	28.8
Livestock and poultry	34.8	37.9	41.3	46.2	51.71	45.9
Forestry	5.3	5.4	4.9	6.6	6.69	2.9
Fishery	86.4	64.9	56.5	46.9	54.17	50.6
Manufacture of wearing apparel and textile	197.3	124.0	116.4	103.2	79.98	57.6
Other manufacturing	82.7	78.7	70.5	64.9	73.51	87.8
Electricity and water	113.3	103.8	111.5	115.0	121.97	131.5
Construction	418.5	539.5	530.4	534.4	518.09	524.1
Wholesale and retail trade	457.8	486.3	549.0	558.0	591.23	623.2
Water transport	143.3	172.3	149.5	145.5	161.06	157.2
Air transport	115.7	114.9	116.6	114.3	123.93	122.6

Other transport services	44.1	69.2	95.8	108.5	105.55	122.7
Communication	153.4	147.2	149.5	165.2	165.42	173.8
Finance	472.3	552.8	579.0	593.2	573.82	583.4
Real estate and ownership of dwellings	412.1	415.4	427.2	433.3	429.94	438.4
Hotels and restaurants	58.2	66.6	57.7	57.5	72.18	74.1
Private health and education services	105.7	108.9	107.2	100.1	126.76	132.2
Business services	462.0	524.3	599.2	619.8	614.85	612.9
Domestic services	50.2	50.8	51.3	51.9	51.94	53.7
Other private services	39.7	43.0	48.0	51.2	52.49	69.7
Government services	1,847.0	2,008.5	2,239.4	2,152.2	2189.73	2,312.5
Memorandum items:						
Population	370,100	383,000	390,000	398,000	406,200	414,400
GDP per capita (in Brunei dollars)	42,864.0	47,587.0	47,329.0	51,251.0	38,433.0	40,702.9

Source: Department of Economic Planning and Development (JPKE)

Appendix: 2

Table: (A2) Brunei Darussalam: Composition of Nominal GDP by Economic Activity, 2005–10

(In percent of total)

	2005	2006	2007	2008	2009	2010
Gross domestic product (GDP)	100.0	100.0	100.0	100.0	100.0	100.0
Oil and gas sector	66.4	68.5	66.8	70.1	60.3	62.0
Oil and gas mining	55.9	59.1	57.4	57.2	47.3	50.8
Manufacture of liquefied natural gas (LNG)	10.5	9.5	9.4	12.9	13.0	11.2
Non-oil and gas sector	33.6	31.5	33.2	29.9	39.7	38.0
Vegetables, fruits and other agriculture	0.1	0.1	0.1	0.1	0.2	0.2
Livestock and poultry	0.2	0.2	0.2	0.2	0.3	0.3
Forestry	0.0	0.0	0.0	0.0	0.0	0.0
Fishery	0.5	0.4	0.3	0.2	0.3	0.3
Manufacture of wearing apparel & textile	1.2	0.7	0.6	0.5	0.5	0.3
Other manufacturing	0.5	0.4	0.4	0.3	0.5	0.5
Electricity and water	0.7	0.6	0.6	0.6	0.8	0.8
Construction	12.0	3.0	2.9	2.6	3.3	3.1
Wholesale and retail trade	2.9	2.7	3.0	2.7	3.8	3.7
Water transport	0.9	0.9	0.8	0.7	1.0	0.9
Air transport	0.7	0.6	0.6	0.6	0.8	0.7
Other transport services	0.3	0.4	0.5	0.5	0.7	0.7
Communication	1.0	0.8	0.8	0.8	1.1	1.0
Finance	3.0	3.0	3.1	2.9	3.7	3.5

Real estate and ownership of dwellings	2.6	2.3	2.3	2.1	2.8	2.6
Hotels and restaurants	0.4	0.4	0.3	0.3	0.5	0.4
Private health and education services	0.7	0.6	0.6	0.5	0.8	0.8
Business services	2.9	2.9	3.2	3.0	3.9	3.6
Domestic services	0.3	0.3	0.3	0.3	0.3	0.3
Other private services	0.3	0.2	0.3	0.3	0.3	0.4
Government services	11.6	11.0	12.1	10.6	14.0	13.7

Source: Department of Economic Planning and Development (JPKE)

Appendix: 3

Table: (A3) Brunei Darussalam: Real GDP by Economic Activity, 2005–10

(In millions of Brunei dollars, 2000 prices)

	2005	2006	2007	2008	2009	2010
Gross domestic product (GDP)	11,463.7	11,967.8	11,986.3	11,753.9	11,546.4	11,846.5
Oil and gas sector	6,201.3	6,469.9	6,023.7	5,650.5	5,388.5	5,504.6
Oil and gas mining	4,773.7	4,977.3	4,577.2	4,150.5	4,008.8	4,075.0
Manufacture of liquefied natural gas (LNG)	1,427.6	1,492.6	1,446.5	1,500.0	1,379.7	1,429.6
Non-oil and gas sector	5,262.5	5,497.9	5,962.6	6,103.4	6,157.9	6,341.9
Government	1,816.5	1,977.6	2,206.5	2,266.8	2,297.9	2,388.2
Private sector	3,446.0	3,520.2	3,756.1	3,836.6	3,860.0	3,953.7
Non-oil and gas sector	5,262.5	5,497.9	5,962.6	6,103.4	6,157.9	6,341.9
Vegetables, fruits and other agriculture	31.3	27.3	28.6	35.3	33.9	34.4
Livestock and poultry	43.8	49.4	50.8	52.5	59.0	55.9
Forestry	5.3	5.4	4.9	6.6	6.7	2.9
Fishery	68.5	52.2	43.9	38.6	41.0	39.3
Manufacture of wearing apparel and textile	173.5	135.0	137.0	132.1	90.4	43.3
Other manufacturing	96.6	83.8	75.5	73.5	68.6	89.6
Electricity and water	85.8	85.9	88.2	89.0	94.6	98.9
Construction	457.8	440.8	488.9	497.6	477.4	488.7
Wholesale and retail trade	486.3	498.8	558.1	561.0	586.4	612.8
Water transport	134.2	144.5	165.1	178.1	200.2	200.5
Air transport	97.7	71.6	72.1	70.5	72.9	72.5

Other transport services	36.9	61.9	100.4	109.3	111.9	134.6
Communication	168.6	163.3	158.8	169.9	170.8	183.4
Finance	417.4	475.6	493.5	505.7	493.4	504.4
Real estate and ownership of dwellings	406.7	408.0	417.4	426.3	424.9	432.3
Hotels and restaurants	46.6	48.2	42.2	42.3	52.9	64.0
Private health and education services	119.8	122.0	97.1	98.2	125.0	136.5
Business services	470.6	542.0	621.4	632.8	630.7	639.9
Domestic services	47.5	48.1	48.4	49.0	49.1	49.2
Other private services	51.1	56.3	63.6	68.3	69.9	70.5
Government services	1,816.5	1,977.6	2,206.5	2,266.8	2,297.9	2,388.2

Source: Department of Economic Planning and Development (JPKE)

Appendix: 4

Table: (A4) Brunei Darussalam: Growth in Real GDP by Economic Activity, 2005–10

(Annual percentage change)

	2005	2006	2007	2008	2009	2010
Gross domestic product (GDP)	0.4	4.4	0.2	-1.9	-1.8	2.6
Oil and gas sector	-2.6	4.3	-6.9	-6.2	-4.6	2.2
Oil and gas mining	-2.7	4.3	-8.0	-9.3	-3.4	1.7
Manufacture of liquefied natural gas (LNG)	-2.2	4.6	-3.1	3.7	-8.0	3.6
Non-oil and gas sector	4.1	4.5	8.5	2.4	0.9	3.0
Vegetables, fruits and other agriculture	-1.3	-12.8	4.8	23.4	-3.9	1.3
Livestock and poultry	-14.5	12.6	2.9	3.3	12.4	-5.3
Forestry	3.9	1.0	-8.5	33.4	1.6	-57.1
Fishery	15.9	-23.8	-16.0	-11.9	6.2	-4.3
Manufacture of wearing apparel and textile	4.6	-22.2	1.5	-3.6	-31.5	-52.1
Other manufacturing	-8.3	-13.3	-9.9	-2.6	-6.6	30.6
Electricity and water	4.1	0.1	2.6	0.9	6.3	4.6
Construction	8.0	-3.7	10.9	1.8	-4.0	2.4
Wholesale and retail trade	2.2	2.6	11.9	0.5	4.5	4.5
Water transport	20.9	7.7	14.3	7.9	12.4	0.1
Air transport	-5.9	-26.7	0.6	-2.2	3.3	-0.4
Other transport services	19.0	67.9	62.2	8.9	2.4	20.4

Communication	-3.2	-3.1	-2.8	7.0	0.5	7.4
Finance	9.9	14.0	3.8	2.5	-2.4	2.2
Real estate and ownership of dwellings	1.2	0.3	2.3	2.1	-0.3	1.7
Hotels and restaurants	-29.5	3.6	-12.5	0.2	25.0	21.1
Private health and education services	68.3	1.9	-20.4	1.1	27.3	9.2
Business services	5.4	15.2	14.6	1.8	-0.3	1.5
Domestic services	1.5	1.3	0.6	1.2	0.2	0.2
Other private services	-8.4	10.2	13.0	7.4	2.4	0.8
Government services	2.9	8.9	11.6	2.7	1.4	3.9

Source: Department of Economic Planning and Development (JPKE)