

Evolution of the electronics and electrical industry in Penang between 1994 and 2013

Upgrading or stagnation?

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Preface

This research is part of the Master Business Geography at the Utrecht University. During the Master course Multinational Corporations, dr. L.M.J. van Grunsven referred with enthusiasm to the opportunity of doing research abroad. And by doing so, he convinced us with his story to apply for doing research in Malaysia. Looking back at this period we definitely have no regrets for doing so.

Following in the footsteps of previous students we started motivated by orientating the theme of this research, the electronics and electronica industry in Penang. In collaboration with the Penang Institute, which provided us with office space, support and a small library, we have had the chance to collect all relevant data for our research. We have resided for five months in a small village near George Town, Batu Ferringgi, where we constructed large parts of our thesis, while having an amazing view on the sea. The experience of being at the other side of the world in a country with completely different cultures and beautiful nature was unbelievable.

During our stay we have also experienced some challenges. It could sometimes be difficult to retrieve information from certain institutions, due to strict regulations. The second big challenge was contacting firms at Penang, because although English is their second language there were a lot of miscommunications. Apart from these difficulties, we have learned much about the electronics and electrical industry, the governmental institutions, the different cultures and the way of living.

Finally, we would like to thank a few people for their support during the completion of this master thesis. First of all, we would like to thank our supervisor Leo van Grunsven for giving us the opportunity of doing this research and for his counseling during the complete process by giving us constructive feedback. Second we both like to thank our family and friends for their full support and patience. And last, we would like to express our gratitude to the colleagues of the Penang Institute, and more specific professor Woo Wing Thye and Miss Siou Woon Ong for their warm welcome and supervision throughout the research.

Raphael Rietema & Daan van der Velden

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List of abbreviations

AMD	Advanced Micro Devices
APAC	Asia-Pacific
APU	Accelerated Processing Unit
ASEAN	Association of Southeast Asian Nations
CPU	Central Processing Unit
CREST	Collaborative Research in Science Engineering and Technology
E&E	electronics and electrical
EI&ME	electronic instruments and measurement equipment
FDI	foreign direct investment
FIZ	free industrial zone
GDP	gross domestic product
GICS	Global Industrial Classification Standard
GNI	Gross National Income
HDD	hard-disk drive
HGST	Hitachi Global Storage Technologies
HP	Hewlett Packard
HQ	headquarter
ICT	information and communication technology
ISIC	International Standard Industrial Classification
IT	information technology
IU	industrial upgrading
LED	light-emitting diode
MIDA	Malaysian Industrial Development Authority
MIMOS	Malaysian Institute of Microelectronic Systems
MSIC	Malaysian Standard Industrial Classification
NCER	Northern Corridor Economic Region
OECD	Organization for Economic Co-operation and Development
PCB	printed circuit board
PDC	Penang Development Center
PPP	public-private partnership
PSDC	Penang Skills Development Center
QCC	quality control certificate
R&D	research and development
RHQ	regional headquarter
RPN	regional production network
SME	small and medium-sized enterprises
SSD	solid-state drive
UNESCO	United Nations Educational Scientific and Cultural Organization
US	United States

Chapter 1: Introduction

1.1 Theme

Over the past sixty years East Asia has become rapidly industrialized. Japan, currently the third largest economy of the world (in terms of gross domestic product), was the first country to start industrializing at a large scale. Japan was soon followed by Hong-Kong, Singapore, South-Korea and Taiwan, together known as the “Asian Tigers” (Yusuf & Nabeshima, 2009). These countries started to industrialize from the mid-1950s and evolved into advanced high-income economies. Their industrialization was mainly driven by an increase in export demand and foreign direct investment (FDI) – primarily from the US – and by higher domestic savings. In order to cope with these changes they have adopted the Japanese economic policies and structure, which are focused on the support of potential leading industries by means of fiscal and trade incentives and the provision of capital on favorable terms. At the same time, the domestic savings were invested in infrastructure and measures were taken to expand the available human capital. The latter was intended to create a skilled workforce ready for the adaptation of technological change.

After the success of the “Asian Tigers” more Asian countries tried to implement similar economic policies. The result was the emergence of a second cohort of countries, consisting of Indonesia, Malaysia, the Philippines and Thailand, which become known as the “Asian Cub Tiger Economies” (Hobday, 1995). These countries adopted similar policies as their predecessors and adjusted the economic models according to their specific regional conditions, strengths and needs. With the implementation of these models they decreased their dependency on natural resources as their main source of income, which was accompanied by an increase of manufacturing activities.

Within many of the “Asian Tigers” and “Asian Cub Tigers” the electronics and electrical (E&E) industry became an important industry (Yusuf & Nabeshima, 2009). The increasing E&E industry stimulated the development of supporting industries and at the same time provided more efficiency and productivity in other industries. Two general approaches towards the development of the E&E industry can be distinguished. The “Northeast Asian pattern”, which can be derived from Japan as the first founding country, followed by the Republic of Korea and Taiwan. This pattern is focused on the creation and development of local firms in order to create economic growth. In contrast, the “Southeast Asian pattern”, aims at industrial development through the attraction of FDI. In the latter pattern, multinational corporations (MNCs) are the driving force behind economic growth (Felker, 2009).

Within Southeast Asia, Singapore has become a global center for research & development (R&D) activities and regional headquarters, due to its early development of the E&E industry. Its neighboring country, Malaysia, experienced a similar, but slightly more limited development. This is displayed by a lingering shift of MNCs from low to medium and high technology operations, the preservation of limited roles of the MNCs’ subsidiaries and limited establishments of MNCs in new technology areas (Henderson & Phillips, 2007). At the same time local supplying industries in the E&E have scarcely developed in Malaysia. This underdevelopment of Malaysia has been referred to as the “middle-income trap” (Woo Wing Thye, 2009; Yusuf & Nabeshima, 2009; Kharas et al, 2010).

Malaysia seems “trapped” between low-income production countries and high-skilled innovative countries. Average wages have increased, so the costs of low-skilled labor are no longer competitive compared to countries such as China or Vietnam. To overcome this issue, Malaysia needs to make the step towards more sophisticated production and functions such as R&D. However, the question arises to what extent Malaysia will be able to compete with countries that already made this step forward, such as Japan, Singapore and South Korea.

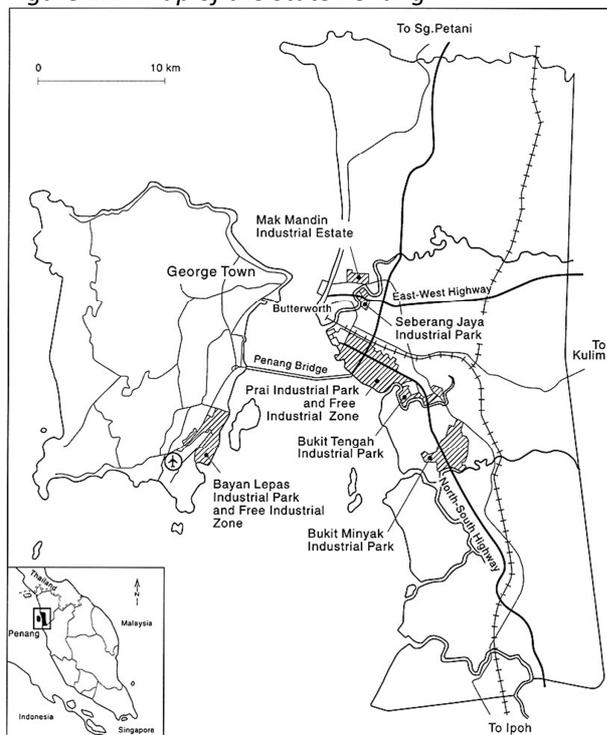
The nature of the problem for Malaysia seems to be related to its economic and technology policies from the 1970s onwards (Kharas et al, 2010). This implies that in order to overcome this “trap” a

revision of the earlier policy framework is required. This revision has been initiated by the Federal Government with the introduction of the “Economic Transformation Programme” in 2010. Within this policy paper the Federal Government focused on a shift from labor-intensive production towards more sophisticated and value-adding production. This process, known as “upgrading”, is necessary to overcome the “middle-income trap” (Government of Malaysia, 2010).

The Penang Context

Penang is an important state in the industrialization process of Malaysia. The state of Penang, one of thirteen in Malaysia, is located on the northwest part of Malaysia. As is illustrated by figure 1.1 below, the state of Penang is separated by the Penang Straits into 2 areas: the island of Penang and Seberang Perai, situated on the mainland (NHERI, 2010).

Figure 1.1: Map of the State Penang



Source: Fold & Wangel, 1997

In the 1970s, Penang was the first state in Malaysia to open a free industrial zone (FIZ), which would become vital for the development of Penang’s economy (NHERI, 2010). The FIZ was established to promote and facilitate the development of export-orientated manufacturing. In 1972, Penang had attracted the first leading MNCs in the E&E industry. The success of the first cohort of MNCs attracted more MNCs to Penang. The inflow of MNCs continued and a growing demand for supplying products resulted in the emergence of supply industries for the E&E industry.

Since the 1970s the economy of Penang has grown impressively. It has transformed from a trading port in the 1950s into a global electronics manufacturing hub. Resulting from this economic growth, wages in Penang have risen. In the meantime countries with more competitive labor costs such as China, Vietnam and India have emerged. As not all MNCs were extensively committed to Penang, some of them chose to move their subsidiaries to other locations with more favorable labor costs (Kharas et al., 2010). A lack of skilled labor, high regulatory burdens and increasing crime rates are a

challenge for Penang in retaining and attracting FDI.

Research question

Since the emergence of the E&E industry in Penang, it has become a significant pillar for the Malaysian economy. Nevertheless, after four decades Malaysia has not been able to make the leap towards high income countries, while other Asian countries such as Taiwan and South Korea did. Since the 1990s and 2000s the government has initiated programs in order to upgrade the E&E industry. The question arises whether these policies have changed the industry over the past two decades. This suggests the following main research question:

“How has the electronics and electrical industry in Penang evolved in the past two decades and how can this be explained?”

In order to answer the main research question the following sub- questions have been constructed:

Industry level

- *How have MNC subsidiary entries and exits between 1994 and 2013 altered the composition of the E&E industry in Penang?*
- *To what extent have MNC subsidiary entries and exits between 1994 and 2013 in the E&E industry in Penang resulted in the emergence of new branches?*
- *To what extent does the evolution of the E&E industry in Penang between 1994 and 2013 reveal up- or downgrading?*

Subsidiary level

- *How have MNC subsidiaries in the E&E industry in Penang evolved between 2004 and 2013?*
- *Which regional characteristics have been conducive to upgrading in Penang between 2004 and 2013?*
- *How has the Southeast Asian network of subsidiaries of MNCs in the E&E industry in Penang changed between 2004 and 2013?*
- *With the results from these questions, how can recent policies focused on upgrading of the E&E industry in Penang be evaluated?*

1.2 Research Aim and Relevance

The aim of this research is in the first place to “map” the evolution of the E&E industry between 1994 and 2013 in Penang at the industry and subsidiary level. The result of this study can give insights in whether the formulated goals of the Malaysian policies can be achieved by continuing with the current approach.

Within scientific literature considerable research is executed on the emergence of the E&E industry in Southeast Asia (further elaborated in paragraph 1.3), as well on the attraction and conservation of FDI by countries and Malaysia in specific. In contrast little is written on the evolution of the E&E industry over time. There is only limited work on the E&E industry in Malaysia mainly from Rasiah (2007, 2009, 2012), Edgington & Hayter (2013) and Yusuf & Nabeshima (2009). The majority of their research so far is mainly executed on a high aggregate level. In this research the focus will be on the industry and firm level. In this way the reasoning behind developments at the industry level can be identified.

This research will follow a similar approach as adopted by Edgington & Hayter (2013) in their study on the development of Japanese firms in Malaysia. In their study they focus on the relationship

between a change in commitment of MNCs to a certain region and their decisions to upgrade their operations in that region. This method is rather new and has hardly been used in research thus far. With this method this research not only attempts to display the evolution of the E&E industry in Penang, but also give insights in the mechanisms behind this evolution.

1.3 State of the art literature on the E&E in Malaysia

As previously mentioned, similar research approaches are limited thus far, especially for the E&E industry in Malaysia and Southeast Asia from the 1990s onward. However, Rasiah (2007, 2009, 2010, 2012), Yusuf & Nabeshima (2009) and Edgington & Hayter (2013) have scrutinized the E&E industry in Malaysia and Southeast Asia. From the early 1970s the E&E industry in Malaysia, the Philippines, Thailand and Indonesia emerged and started to grow fast. But whereas Korea and Taiwan experienced a transition from assembly activities towards designing and development operations, Malaysia, Indonesia, the Philippines and Thailand did not manage to achieve a similar upgrading of activities (Rasiah, 2010).

From the results of different studies, a closer look at the E&E industry in shows that the industry did evolve in terms of in terms of size and composition of firms, of products and of skill composition of the workforce (Rasiah, 2009; 2010 ; Yusuf & Nabeshima, 2009). At the same time these developments seem to have had little impact on the process of catching-up. As Rasiah (2010) observes there is still a low participation of firms involved in higher technological operations and thus the E&E industry in Malaysia seems to require further and faster technological upgrading in order to strengthen the competitiveness of the industry. The study by Edgington & Hayter (2013) on the development of Japanese firms in the E&E industry in Malaysia yielded similar results. Resulting from a lack of skilled labor, firms have not been able to upgrade their activities and further technological dynamics have been limited.

1.4 Approach

This research consists of two parts, according to the level of analysis. The first part is focused on the E&E industry as a whole. For this section an inventory of the size and composition of the E&E industry in Penang in 1994 is made. All the data gathered is collected in a database. By means of this database, from 1994 onwards the evolution of each branch will be analyzed. With this analysis a closer look will be taken at the entries and exits and the changes of the composition of the industry over time.

In order to understand the mechanisms behind the changes at the industry level surveys were conducted with respondents from MNCs. In the second part the focus lies on the MNCs within the E&E industry and more specifically their subsidiaries operating in Penang. The analyses of the data gathered in the database at industry level and supplemented by the interviews at the subsidiary level will answer the central question of the research. The methodology of this research described in chapter 4 will elaborate in more detail on the execution of the research.

1.5 Outline of the thesis

The thesis is divided in 7 chapters. As this chapter described of the context of the E&E industry in Penang in Southeast Asia, chapter 2 presents an overview of all relevant theories resulting in a conceptual framework. In chapter 3 the current characteristics of the region of Penang are elaborated, after which the hypotheses of this research are formulated. In Chapter 4, the methodology of the research will be discussed. Thereafter the results of the research on the evolution of the E&E industry as a whole and on firm level are presented. The final chapter will give an answer to the proposed research question and discusses any stated problems.

Chapter 2: Theoretical Framework

This chapter presents an overview of the relevant theoretical concepts regarding evolution. Since subsidiaries of MNCs in the E&E industry are the main research units, evolution expresses itself at two levels of analysis: the industry-level and the subsidiary-level. This distinction between industry and subsidiary level is used throughout the framework. The first part starts with the highest geographical scale: the industry-level. The second part covers the subsidiary-level.

The remainder of this chapter starts with explaining the concept of branching and industrial upgrading. This is followed by the factors influencing branching. The second section covers the concepts of in situ upgrading and factors behind evolution on the subsidiary level. The final paragraph presents a conceptual framework in which all relevant concepts are encompassed.

2.1 Industry level evolution

As described above, changes at the industry level can help identify key developments within the E&E industry in a region. While an industry consists of several branches, a branch consists of a group of firms – in this research restricted to firms within the E&E industry – that produce (strongly) related products. For instance, the Light-Emitting Diodes (LED) branch consists of firms that all produce LED-devices or applications. Throughout the years, new branches may emerge, while others cease to exist. This affects the composition of the industry as a whole. A way of identifying the development of an industry is by looking at changes of and within its branches.

2.1.1 Branching

Boschma & Frenken (2009) define the process through which diversification of a branch leads to the emergence and expansion of (new) related branches as *branching out*. New branches can emerge in two different ways. A branch can emerge out of a related established branch or a branch can emerge through the recombination of different competences from several related branches. In the first case, related firms in terms of products, processes and technology enter the industry and non-related firms leave the industry. In the second case, regional diversification can lead to new combinations. This means that the emergence of a new branch is influenced by the composition of an industry (Neffke et al., 2011). Branches that are technologically related to the established branches industry are more likely to emerge than branches that are not related. Boschma (2005) refers to this concept as related variety.

The regional composition of branches within an industry may evolve from year to year (Boschma, 2011; Neffke et al., 2011). Some branches enter the industry, while others cease to exist. Klepper (2001; 2002) identifies three ways in which new branches emerge within an industry. First, existing firms can diversify their scope of related products and/or activities. Second, entrepreneurs can establish new firms. Third, former employees start a new firm in the same or in a related branch. Firms resulting from the latter are called *de novo* spin-offs. Spin-offs can be a primary source of innovation, although they can also limit the opportunities for incumbent firms to compete. As a result, in some industries, many firms can be traced back to one or several firm(s). For example, many leading semiconductor firms (e.g. Intel) are a former spin-off from Fairchild Semiconductor.

With respect to firm entries, Van Grunsven & Witte (2012) make a distinction between endogenous development and exogenous implantation. Endogenous development refers to entries of firms from within the local environment through entrepreneurship or spin-offs as discussed above. Exogenous implantation refers to the establishment of subsidiaries by foreign MNCs. Although in the long run, the path of endogenous development is favored by some scholars (Frenken & Boschma, 2009), van Grunsven & Witte (2012) argue that for late-industrializing countries such as Malaysia the impact of exogenous implantation requires more attention.

Related branches with a high degree of variety will exhibit more learning opportunities and more

local knowledge spill-overs than related branches with a very low degree of variety (Frenken et al., 2007; Boschma et al., 2012). Effective knowledge transfers require some, but not too much cognitive proximity (related knowledge) between firms. As too much cognitive proximity can lead to lock-in, too little cognitive proximity can lead to ineffective communication and learning (Nooteboom, 2000). As stated by Neffke et al. (2011, p. 241):

“A range of technologically related industries in a region should be more beneficial than a diversified but unrelated set of industries because related industries combine cognitive distance with cognitive proximity bringing together the positive aspect of variety across and relatedness among industries”.

An example of technologically related industries leading to new combinations or innovations is found in Germany where the development of the car industry was boosted by highly skilled aeronautic engineers who lost their jobs in the airplane industry but found work in the car industry. In the car industry they could use their skills to lift the car industry to a higher level (Neffke & Henning, 2012).

With respect to the above it should be noted that the literature specifically focused on branching, which actually explains inter-industry branching. As these theories describe how entire industries emerge within an economy, for this research the reasoning behind these theories is translated to the industry level and used to explain intra-industry branching. For the remainder of this thesis, branching out refers to a changing composition of branches within an industry.

2.1.2 Industrial upgrading

The concept of industrial up- or downgrading refers to result of branching by looking at the changes in the composition of an industry. Industrial up- and downgrading are two opposite outcomes of the evolution (of the composition) of an industry. In case the composition of an industry has become more sophisticated, evolution has resulted in industrial upgrading. This can result from overall productivity upgrading, expanding the range of functions within the industry, or moving to adjacent categories of branches of increased technological sophistication (UNCTAD, 2013). It can mean jumping into branches several levels up the technology ladder. If the branches of an industry have developed themselves in such a way that the overall composition of the industry has become more sophisticated compared to a previous stage in development, the industry has upgraded. If the overall composition has become less sophisticated, the industry has experienced downgrading.

2.1.3 Factors influencing the branching process

To emphasize the above theories, an industry is composed of several branches. Changes in this composition are being influenced by several factors. The first factor conducive to branching are changes within the product portfolio of a single subsidiary. A subsidiary could, for instance, start making different products, thus “creating” a new branch of subsidiaries that make related products. Particularly when this concerns large subsidiaries with roots in the region, a wide customer basis, a narrow product portfolio that are well-embedded within their region (Grunsven & Witte, 2012). When they also train their workforce and create a high(er) absorptive capacity of knowledge in the region, spin-offs could easily be established. Spin-offs are of great importance for the creation of new branches.

The second factor influencing branching firm entries and exits. This can occur as a result of spin-offs, but also through entrepreneurship, or exogenous implantation as previously described. Whether new firms do or do not enter the industry in a region and the success rate of these entries depends on past developments within the region. If a firm establishes within a region with many unrelated firms, it is likely to exit the region (or shutdown).

The third factor is derived from the evolutionary economic geography and is called “path dependency”. Decisions made by a firm and capabilities gained in the past determine the current

development of firms and thus indirectly influences the composition of branches and industries. This means that the current state of an industry is to large extent determined by decisions that were made and by capabilities and experiences gained in the past (Boschma et al., 2002). Path dependency is also an explanation for the unequal distribution of economic activity across regions as an outcome of historical processes. The probability that something occurs in a specific region is affected by the events that have already taken place in the past (Boschma & Frenken, 2007). Additionally, the economic performance of a firm is influenced by the moment of entering an industry. Firms that enter an industry in an early phase will face better growth opportunities than the ones that enter later.

A final influencing the regional composition of branches within an industry, is the natural change that occurs within an industry. All industries have a unique development path, which is influenced by global changes such as technological progress. The E&E in particular, is a fast-changing industry in which technological advancements frequently occur.

2.2 Subsidiary-level evolution

As discussed above, changes at the industry level occur partly as a result of changes within a subsidiary. At the subsidiary level, in situ evolution is expressed by changes in the subsidiary's functions, its product portfolio and its production processes. The position of a subsidiary within the MNC may change and its charter may change accordingly. The evolution of a subsidiary can follow different trajectories. The outcome of this evolution process, as with industrial upgrading, can be negative or positive. This is being coined in situ upgrading or downgrading.

2.2.1 In situ upgrading

A subsidiary can evolve by changing its functions, its product portfolio and its production processes. Functions of firms may change over time, for instance from simple manufacturing activities to complex research & development (R&D) activities. Apart from changes between functions, changes within a function can also occur, for instance from low-end to high-end manufacturing. As illustrated in table 2.1 below, Rasiah (2010) has developed a taxonomy with six levels of knowledge depth activities linked to a firm's technological capabilities. The development of firms' technological capabilities can be analyzed on three areas: human resources, processes and products. In the first three levels, the workforce is characterized by in-house training and prepared for low-end activities like assembling, components processing, precision engineering and quality controlling using simple machinery. In the last three levels, the workforce consist of hired and well-educated engineers and scientists concerned with innovation activities as adapting and developing existing and new products using sophisticated machinery, equipment, materials and techniques (Rasiah, 2010).

Table 2.1: Taxonomy of firms' technological capabilities

Knowledge depth	Human Resource	Process	Product
<i>Simple activities</i>	On the job and in-house training	Dated machinery with simple inventory control techniques	Assembly or processing of components, CKD and CBU using foreign technology
<i>Minor improvements</i>	In-house training and performance rewards	Advanced machinery, layouts and problem solving	Precision engineering
<i>Major improvements</i>	Extensive focus on training and retraining staff with training responsibility	Cutting-edge inventory control techniques, SPC, TQM, TPM	Cutting-edge quality control systems (QCC and TQS) with OEM capability
<i>Engineering</i>	Hiring engineers for adaptation activities; separate training department	Process adaptation: layouts, equipment and techniques	Product adaptation
<i>Early R&D</i>	Hiring engineers for product development activities; separate specialized training activities	Process development: layouts, machinery and equipment, materials and processes	Product development capability. Some firms take on ODM capability

<i>Mature R&D</i>	Hiring specialized R&D scientists and engineers wholly engaged in new product research	Process R&D to devise new layouts, machinery and equipment, prototypes, materials and processes.	New product development capability, with some taking on OBM capability
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Source: Rasiah, 2010

Note: CKD, complete knock-down; CBU, complete built-up unit; SPC, statistical process control; TQM, total quality management; TPM, total preventive maintenance; QCC, quality control circles; TQC; total quality control; OEM, original equipment manufacturing; ODM, original design manufacturing; OBM, original brand manufacturing.

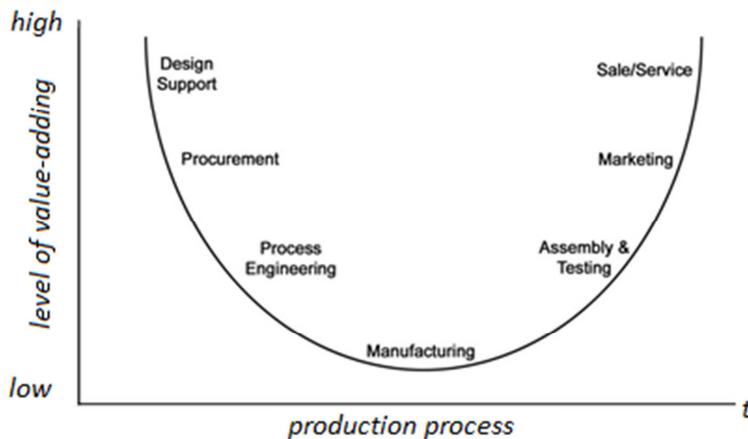
In this taxonomy, subsidiary-upgrading represents the shift from lower levels to higher levels. However, firms can cover different levels at the same time. Only firms on level five and six can actually contribute to the development of new products and technologies, but they are not necessarily able to reach the highest levels of the taxonomy. It should be noted that in his taxonomy, Rasiah (2010) links a firm’s capabilities (the knowledge depth and human resource columns) directly to the level of process and product sophistication.

Ernst (2003) defines the concept of in situ upgrading differently:

“...a shift to higher value-added products, services and production stages through increasing specialization and efficient domestic and international linkages, industrial upgrading necessitates a strong domestic knowledge base.”

Although they use a different line of phrasing, Rasiah (2010) and Ernst (2003) both label in situ upgrading as a result of changes in a subsidiary's functions, products and processes. Furthermore, they both emphasize the difference between functions in terms of value-added.

Figure 2.1: Value-added functions within the firm.



Source: Economic Planning Unit & The World Bank (2011)

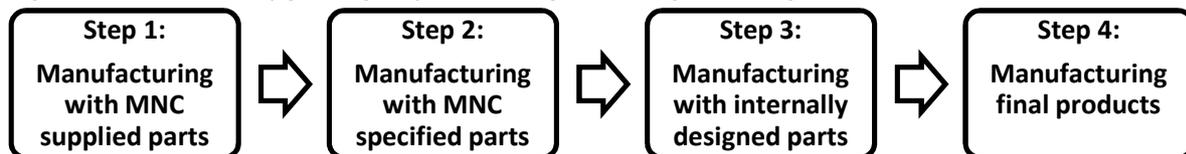
Value-added is defined as the sum of the profit that is made by the execution of a function or service, including the depreciation costs that were made and the labor costs. In the “smile curve” displayed in figure 2.1 above, different functions within the value chain are linked to their added value (Economic Planning Unit & The World Bank, 2011). At both the start and the end of the production process the activities are adding the most value; design and procurement at the start and sale/services and marketing at the end. The engineering, manufacturing and assembly & testing activities add the least value to the product. Following this conceptualization, in situ functional upgrading can mean a shift from a lower level value-adding activity to a higher one. For example, the shift from manufacturing towards

assembly & testing would imply functional upgrading.

Azadegan & Wagner (2011) give an example of a subsidiary's development path from simple to more complicated activities. In this path, they make a distinction between four progressive steps a subsidiary can make in the upgrading process as is illustrated by figure 2.2. With each step extra value-adding processes are added to the subsidiary's operations. In their concept Azadegan & Wagner (2011) use the relationship between the late entry of a manufacturing subsidiary and an existing (foreign) subsidiary to describe this process. In this case, their concept is applied to the relationship between an MNC and a manufacturing subsidiary.

In the first step, the new subsidiary starts to perform basic activities such as manufacturing low value-added parts and products and (sub)assemblies with parts supplied by the MNC. The MNC basically uses the subsidiary as a simple production and assembly site, granting it hardly any own responsibilities. In the next step, the MNC asks for specified parts to be used for manufacturing and procurement of materials is added to the charter of the subsidiary. In the following step, the subsidiary initiates the manufacturing of products that are internally designed and R&D is added to the charter of the subsidiary. In the final step, the subsidiary manufactures final products, which are designed locally.

Figure 2.2: Industrial upgrading steps according to Azadegan & Wagner (2011).



Source: Azadegan & Wagner (2011), own draft

In conclusion, functional upgrading at the subsidiary-level is related to the amount of value-added that a certain activity will yield. With respect to products or processes, not the amount of value-added but rather the sophistication of the product and production process is important. Furthermore, whether a subsidiary produces with parts supplied by the MNC, or rather produces final products itself determines the step in the upgrading process that Azadegan & Wagner (2011) distinguish.

2.2.2 Subsidiary's internal and external embeddedness & locational commitment

In the steps distinguished by Azadegan & Wagner (2011), an important factor influencing the evolution of subsidiaries already became evident: the MNC's strategy. An MNC's HQ or RHQ will constantly evaluate and assess the performance of all subsidiaries. This decision following this evaluation determines when a subsidiary advances a step in the model derived from Azadegan & Wagner (2011) as displayed in figure 2.2. Furthermore, the evaluation determines how well a subsidiary is embedded within the corporate network of the MNC (internal embeddedness) and, in turn, within the region in which it operates (external embeddedness) (Meyer et al., 2011).

Since the focus of this research is on local subsidiaries of MNCs, one of the factors influencing evolution of these subsidiaries is how well they are embedded within the region in which they operate. Andersson & Forsgren (2000) argue that there is a positive relationship between the strategy of an MNC and the local embeddedness of a subsidiary. At the subsidiary level, the local relationships of a subsidiary with specific clients/customers and suppliers are an important determinant for its position within the MNC and for its future influence on the global strategy of an MNC. Embedded subsidiaries can provide access to a variety of competencies (Andersson et al., 2007). As Andersson et al. (2005) argue, innovative activities originate as much from behavior within a single subsidiary as from relationships with other firms. The stronger its relationship with other firms becomes in terms of interaction and mutual trust, the more likely it becomes for a subsidiary to perform well. In this perspective, not all MNC subsidiaries

have equal opportunities to learn from each other. This depends both on the business partners of the subsidiary and its ability to identify opportunities. Local external relationships of a subsidiary enhance its abilities to absorb new skills and knowledge from its environment.

Meyer et al. (2011) define this aspect of local embeddedness with regard to a subsidiary's relations in the host country as external embeddedness. In addition to external embeddedness, they also point out the importance of internal embeddedness of a subsidiary within the MNC. The trade-off between the subsidiary's role within the MNC and its local relationships can be challenging. The MNC can influence the subsidiary's local embeddedness and vice-versa. The HQ will try to achieve that the subsidiary behaves in accordance with the MNC's goals. On the other hand, positive experiences with a region and the quality of the performance of the subsidiary (induced by its embeddedness within the region), determine the commitment of an MNC to that region. In this research a distinction is made between the two forms of embeddedness as described above, and locational commitment. As both internal and external embeddedness are related to the subsidiary level, locational commitment refers to the attitude towards the subsidiary and its region from the perspective of the MNC itself. In the end, an MNC's HQ will evaluate the subsidiary and decide whether to allow that subsidiary to upgrade.

2.2.3 An MNCs network: the regional production network

Inherent to being an MNC are decisions on locational strategies. As an MNC consists of an HQ in the country of origin and at least one foreign subsidiary, the MNC must make choices on the allocation the functions within their value-chain. The contemporary global economy is characterized by such value-chains to a large extent coordinated by MNCs (UNCTAD, 2013). In a global value-chain (GVC), the different intermediate goods and services are no longer concentrated in one country, but geographically dispersed and integrated in an international production network (Ernst & Kim, 2002; OECD, 2013). The emergence of GVCs is driven by technological progress, cost-cutting strategies of MNCs, access to resources or markets and trade policy reforms (OECD, 2013).

Since the focus within the international network of an MNC in this research remains at the region of Southeast Asia, the international production networks are referred to as regional production networks (RPNs). The activities within an RPN occur at multiple geographical scales which are interrelated (from local and regional to national and global and vice versa) (Henderson, 2002). Three macro-scale trends have stimulated the rise of RPNs: increased liberalization, development and diffusion of information and communication technologies, and increased competition (Ernst & Kim, 2002).

The actual drivers behind RPNs are MNCs with their foreign subsidiaries. While the decision-making process within the RPN takes place at the MNC's (regional) HQ, the MNC's subsidiaries carry out production functions such as assembly, manufacturing, R&D or a combination of different activities. The past decades, MNCs have also increasingly relocated and assigned R&D activities to established subsidiaries (Diez & Bergero, 2005). Based on the roles and corresponding activities of a subsidiary, Dörrenbacher & Gammelgaard (2006), distinguish five different types. First, a subsidiary can act as a *marketing satellite*. They market a single or a range of products in the host country and can provide only limited services. Second, a subsidiary can be a *miniature replica*. Besides marketing, they are engaged in manufacturing several products for the parent company. Third, *rationalized manufacturers* produce for other markets as well. Fourth, *product specialists* are responsible for product development, manufacturing and world-wide marketing. Fifth, so-called *strategic independent units* are free to set up new markets for products that they develop and manufacture.

Apart from intra-firm transactions, inter-firm transactions can be covered in an RPN as well. RPNs are coordinated by MNCs through linkages between local suppliers, service providers and other partners carrying out activities for the MNC (Ernst & Kim, 2002; Ernst, 2004). This governance of the RPN by the MNC can express itself in various modes, from direct ownership of foreign affiliates to contractual relationships (UNCTAD, 2013).

2.2.4 Subsidiary charter development

As seen above, a subsidiary's position within the MNC can change substantially over time. The position of a subsidiary is interrelated with its MNC's strategies and can be subject to change. According to Birkinshaw & Hood (1998), change or development of a subsidiary's position can express itself through its capabilities and its charter which are inescapably intertwined. The subsidiary's capabilities are shaped by its capacities and routines. These capacities and routines combined with its resources determine a subsidiary's output potential. The subsidiary's charter encompasses all its activities from production to marketing and the provision of services assigned by the parent company.

Drawing on previous research by White & Poynter (1984), Dörrenbächer & Gammelgaard (2006) distinguish three dimensions of subsidiary charter development. First, change of its market scope by entering new geographic markets. Second, new product creation by expanding its current production or creating a completely new product. Third, development of the production process whereby more value-added activities as marketing, logistics or R&D are carried out. To what extent these processes take place, depends on the subsidiary's capabilities, the HQ's strategy and locational (regional) factors or localization advantages (Birkinshaw & Hood, 1998; Dörrenbächer & Gammelgaard, 2006; 2010; Paterson & Brock, 2002; Rodrigues, 1995).

The extent to which a subsidiary has unique, scarce and irreplaceable value-adding resources such as a high skilled workforce, organizational routines or learning processes determines the competitiveness and therefore the subsidiary's position in the local environment (external embeddedness) and relative to other subsidiaries in the RPN (internal embeddedness) (Dörrenbächer & Gammelgaard, 2006). The HQ's intended strategy plays an important role in the development of the subsidiary's charter as well. This strategy is not final, especially when this strategy has an unsatisfying result for the subsidiary's charter. Subsequent negotiations between the HQ and the subsidiary can result in a change of the HQ's intended strategy into a more satisfying outcome for the subsidiary: the HQ's realized strategy. The extent to which the HQ is dependent on the subsidiary is determined by the quality of the capabilities of the subsidiary. The stronger the dependence of the HQ, the stronger the subsidiary's position during the negotiations over its charter (Dörrenbächer & Gammelgaard, 2006; Dörrenbächer & Gammelgaard, 2010).

There is another factor of substantial influence on the decision making process of an HQ when it has to make decisions on a subsidiary's charter, which is centrality. Dörrenbacher & Gammelgaard (2010, p. 209) refer to Ghoshal & Bartlett (2005) and define an actor's point of centrality in a network as:

"...the number of other actors within the MNC network with which it has direct exchange relations."

Another approach of measuring centrality is the extent to which one actor is indispensable for the total network. In other words: actors with a high degree of centrality leave – if removed from the network – a high number of other actors in the network disconnected. Applied on RPNs, centrality would measure the extent to which other subsidiaries and the HQ are dependent on a single subsidiary. As became clear in the above, a dominant position within the RPN gives that subsidiary a better bargaining position during the negotiations over its charter.

With all this in mind, the HQ usually still have multiple subsidiaries to choose from. This means that a firm can decide which subsidiary within its RPN is eligible for upgrading its charter and which is not (Ernst & Kim, 2002; Ernst, 2004). In addition, other factors such as bureaucracy, rivalry, conflicting interests, lack of recognition or just personal preferences can influence this process, so that creative ideas or initiatives proposed by the subsidiary may hardly have any chance of approval.

2.2.5 Regional characteristics

As discussed above, external embeddedness and locational commitment are both related to the extent

to which a firm (or its subsidiary) is tied to the region it operates in. As the degree of locational commitment differs from firm to firm, the characteristics of a region have another impact on each firm. Favorable regional characteristics may even be a major reason why a MNC chooses to establish a subsidiary in a certain region in the first place. However, it has to be noted that the influence of local factors on horizontally integrated value chains (as is the case with MNCs) is different on vertically integrated value chains (all steps of the production process in one place). Furthermore, horizontally integrated value chains often have fewer factors that are of influence than vertically integrated value chains. When for instance an MNC decides to allocate one part of the value chain in region x, only the regional characteristics relevant for that activity within the value chain influence the HQs decision. However, in case a firm has all parts of the value chain incorporated in one establishment, there are more regional characteristics that matter (UNCTAD, 2013).

According to Meyer et al. (2011) local environments particularly differ in two dimensions: the institutional dimension and that of resource endowments. They define these dimensions in a very broad manner. Hence, the institutional dimension ranges from all formal (legal, political, administrative, governmental) to all informal (relationships and social norms) institutions. Subsequently, Meyer et al. (2011) note that these institutions are – in contrast with most MNCs – bound to a specific region. Resource endowments are defined equally broad and range from natural resources to human capital. With respect to this dimension, for firms both the resource endowments of the host- and the home region are important.

Edgington & Hayter (2013a) distinguish three different ideal-types of FDI dominated clusters within regional economies: regional economies characterized by *assembly clusters*, *embedded clusters* or *technology clusters*. Regions with an over-representation of assembly clusters, as well as Martin's (2005) regions as sites of export specialization are characterized by low labor costs and multiple investment incentives like export subsidies, free trade zones and attractive tax regimes. Competition between these kind of regions is primarily based on costs and can therefore be attractive for large MNCs looking for low-cost production. As MNCs are increasingly foot-loose in their operations, they can shift between these regions in case one of them has an edge over the others in cost-efficiency. This is both an opportunity for these regions (if relative costs decrease, they might attract new subsidiaries) and a threat (if relative costs decline in competing regions, MNCs might leave).

Regions with embedded clusters are characterized by low taxes, a good infrastructure, a skilled workforce and the ability of local supplying firms to absorb knowledge. These clusters have the capacity to have technological process changes easily adopted by local suppliers. Therefore, MNCs in these regions will have these changes faster and easier (more efficiently) implemented in their production process than MNCs in other regions. Strong linkages and collaboration of MNCs with local suppliers and local knowledge institutions lead to more external embeddedness of MNCs.

In regions with technology clusters (referred to by Martin (2005) as “regions of knowledge hubs”) MNCs collaborate intensively with local sources of technology such as research institutes and universities, acquire technologies from suppliers and/or recruit experienced technicians or engineers. Competition takes place on sophisticated production and corporate capabilities. In these knowledge hubs, MNCs heavily depend on local external information and expertise that leads to an even higher external embeddedness. These regional economies can be associated with science parks, high-standard educational institutions and a fast and easy knowledge/technology transfer rate from and to local suppliers and engineers.

MNCs tend to have geographically dispersed value chains. To maximize their benefit from these horizontally integrated value chains, good connectivity (in terms of both “soft” and “hard” infrastructure) is vital for MNCs. Soft infrastructure entails all institutional conditions, i.e. good governance and sound legal structures. This is, for instance, important to facilitate cross-border human capital exchange and allow people to easily switch jobs between different firms. Hard infrastructure involves harbors, airports,

railroad systems, roads, ICT systems and all other physical infrastructure available in the region. This is particularly important for MNCs since they ultimately have to connect all “pieces of the value chain puzzle” in order to get their finished product. Also, just-in-time approaches benefit from a good hard infrastructure. Related to just-in-time production is the local supply base. In a market that is highly penetrated by local suppliers, it is easy to find the suitable supplier. And if the relationship with that particular local supplier turns out to be less beneficial than expected, there are plenty alternatives (OECD, 2013).

2.2.6 Characteristics of the E&E industry

The characteristics of the E&E industry differ from other industries. With the invention (and the wide application) of integrated circuits (ICs) in the mid-1960s the E&E industry evolved rapidly. The controlling and governing properties of ICs make the E&E a technology-creating industry (Rasiah, 2010). Technological developments heavily influence the entry and exit of firms and thus the emergence of branches (Boschma & Frenken, 2009). The use of ICs provides enabler synergies in a wide variety of industries and especially in related branches within the E&E industry. Meanwhile, the capacity of ICs has increased rapidly. The number of transistors on ICs is doubled approximately every two year, a cycle also referred to as Moore's law following his publication in 1965 (Moore, 1965). As a result of this trend, the major driver for IC development has been miniaturization by scaling down transistors (IRC, 2012). Because the semiconductor industry managed to dramatically decrease costs per elementary function within the ICs, this enabled the emergence of entirely new markets.

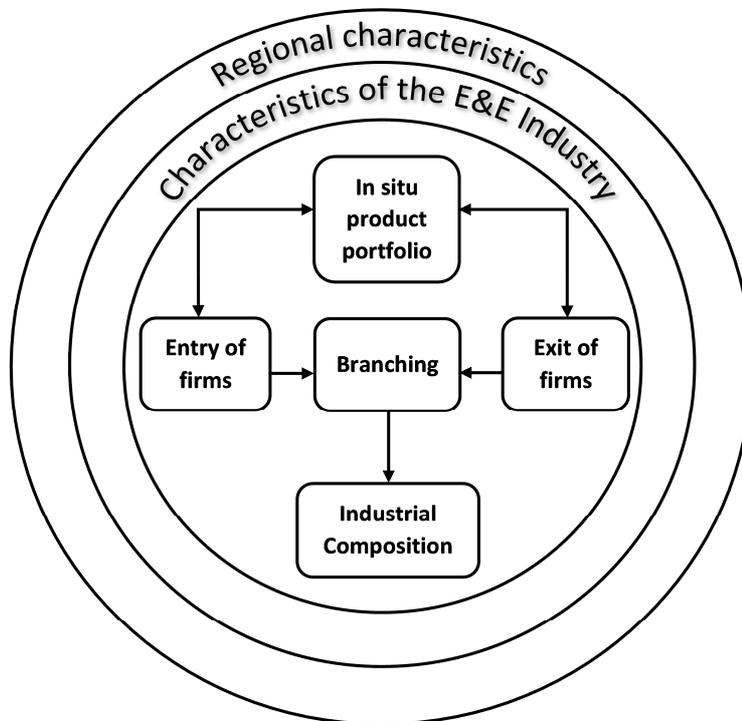
The improvements in ICs are characterized by developments in six fields (IRC, 2012): integration level (more transistors on one chip), costs (lower costs per function), speed (increased microprocessor performance), power consumption (longer battery life), compactness (downscaling) and functionality (wide application). As ICs are practically used in all electronic products, these developments have fueled related branches. This resulted in improvements in branches as diverse as ranging from telecommunications and hard-disk drives to medical devices. Overall, products and devices in the E&E industry have become more complex, cheaper, faster, and compact.

With respect to the composition of the E&E industry, the rapid developments within the industry out branching in another perspective compared to other industries. As new technologies arise, new branches emerge accordingly. On the other hand, new technologies can also make older branches obsolete. From this perspective, the fast changes within the E&E industry can be expected to accelerate the branching process compared to “conventional industries”.

2.3 Conceptual framework

As this research makes a distinction between industry and subsidiary level evolution, this distinction is also visible in the conceptual framework. As illustrated by figure 2.3 below, the industry level conceptual framework has as ultimate dependent variable the “industrial composition”. Overarching factors that influence this composition are the general regional characteristics and the specific characteristics of the E&E industry. Since some industries evolve differently from others, this factor is incorporated in the model explaining evolution of the composition of an industry. The iterative cycle that (within the framework of the characteristics of region and industry) leads to the evolution of the industrial composition consists of another four factors: the product portfolio of MNC subsidiaries; MNC subsidiary entries; MNC subsidiary exits; and finally, (through the concept of branching) the composition of the industry.

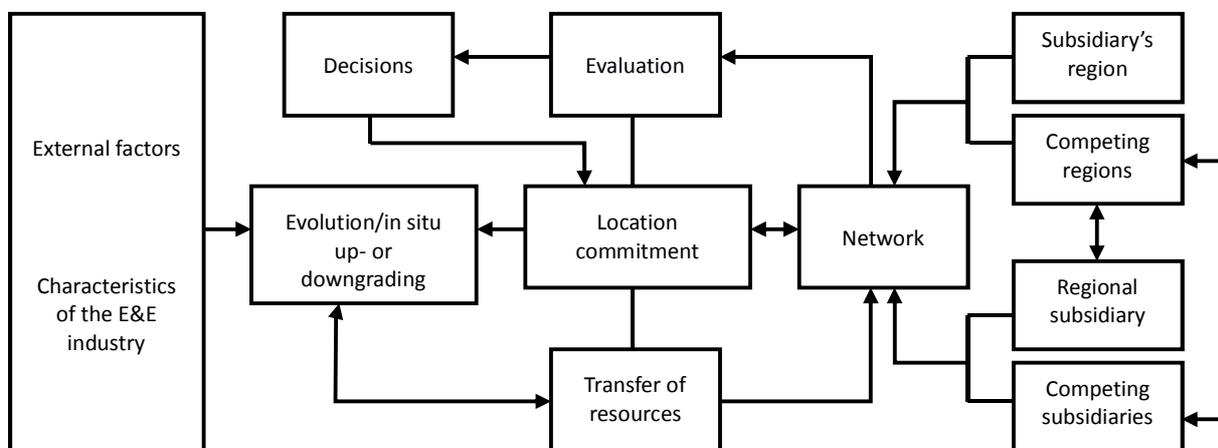
Figure 2.3: conceptualization of the relevant theoretical aspects of industry level evolution.



Source: own draft

The conceptualization of subsidiary level evolution can be seen as an elaboration of the “in situ product portfolio” factor in the industry level conceptual framework. As well as in the industry level model, the subsidiary level model below (see figure 2.4) includes an iterative cycle of causalities in the center, with evolution/in situ up- or downgrading as ultimate dependent variable. This is influenced by five factors: characteristics of the industry; characteristics of the subsidiary’s region; competing regions; capabilities/charter of the subsidiary; and capabilities/charter of competing subsidiaries. The top half of the cycle visualizes the decisions of the MNC on subsidiary charter development. In the center, position within the RPN as well as locational commitment/external embeddedness are distinguished. External factors, as well as regional characteristics and characteristics of the E&E industry are factors the subsidiary nor the MNC has direct impact on, but in turn might impact upgrading.

Figure 2.4: conceptualization of the relevant theoretical aspects of subsidiary level evolution.



Source: own draft

Chapter 3: Current conditions of the regional characteristics of Penang

In this chapter the conditions for upgrading, based on the regional characteristics in the theoretical framework, are analyzed for the region of Penang. In the first paragraph Penang is introduced by presenting an overview of its key characteristics. Thereafter, the second paragraph describes all relevant regional conditions for MNC subsidiaries in Penang. Finally, this chapter ends with a conclusion and hypotheses following from the theoretical framework, its conceptual framework and the regional analysis presented in this chapter.

3.1 Regional Characteristics

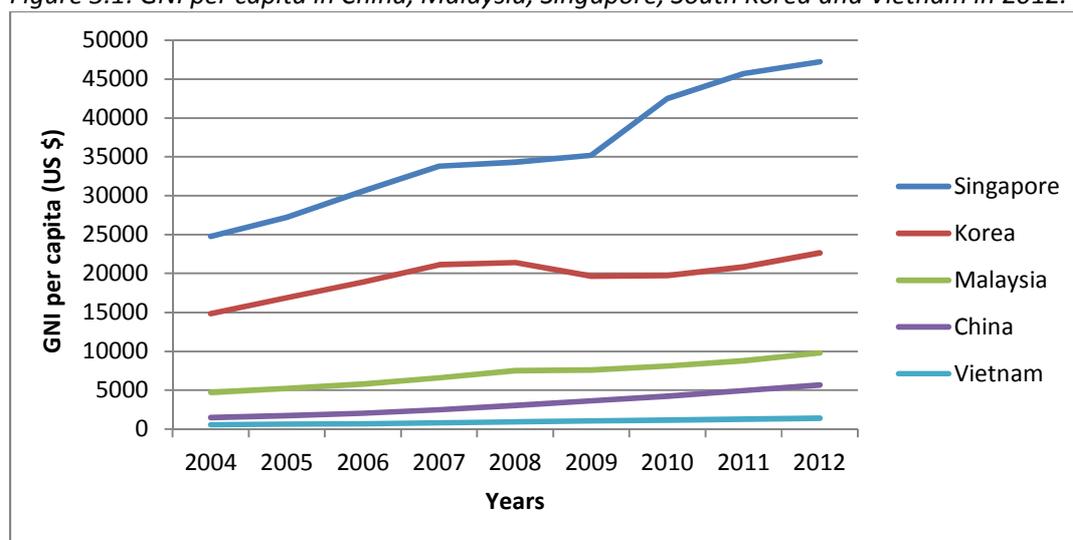
As mentioned in the theoretical framework, the degree of locational commitment of an MNC and the external embeddedness of its subsidiary are related to the region wherein the subsidiary operates. In this paragraph the relevant regional characteristics of Penang are described.

Labor pool and education in Penang

The success of investments in high-tech activities is subject to the availability of the skilled labor. As previously stated, Penang is the most densely populated state of Malaysia. In 2012 the labor force participation rate was 68.8 percent, resulting in a total labor force of 786.100 workers (Department of Statistics, 2013). This labor force is unequally dispersed among the 5 districts, of which Timur Laut – with the metropolitan city George Town – has the highest population density (NHERI, 2010, p. 3). Although male participation is higher with 80.9 percent, female participation in Penang is highest in Malaysia, with 57.5 percent (Department of Statistics, 2012a). The traditionally high female participation in the E&E industry is the main reason for the difference with the other states (Rasiah, 2010, p. 302). Overall unemployment in 2012 in Penang was significantly lower with 2 percent compared to the overall unemployment of 3.1 percent in Malaysia (Department of Statistics, 2013a).

As is mentioned in the introduction, Malaysia has become a middle income country. With a gross national income (GNI) of nearly \$10.000 per capita Malaysia has compared with China a much higher GNI (per capita) of approximately \$6.000. On the other hand Malaysia is compared to Korea and Singapore lagging far behind (see figure 3.1). Having a closer look within Malaysia, Penang has the second highest average wage at the state level behind Selangor (Department of Statistics, 2013b).

Figure 3.1: GNI per capita in China, Malaysia, Singapore, South Korea and Vietnam in 2012.



Source: The World Bank (2013), *edited*

Note: The GNI per capita presents the dollar value of a country's final income in a year balanced against the population.

The percentage of higher education enrollment in the cohort of 19 to 24-year old population is a fundament for the access to high skilled labor in the future. Although statistics of Penang-specific enrollment figures were unavailable, the proportion of enrollment in Malaysia has grown tremendously from 11 in 1995 to 42 percent in 2010 (The World Bank, 2013). Noteworthy is the large number of Chinese students (60%), followed by Malays, Indians and other, when it comes to ethnicity (NHERI, 2010).

Table 3.1: R&D researchers and engineers per million of the population from 1996 to 2006.

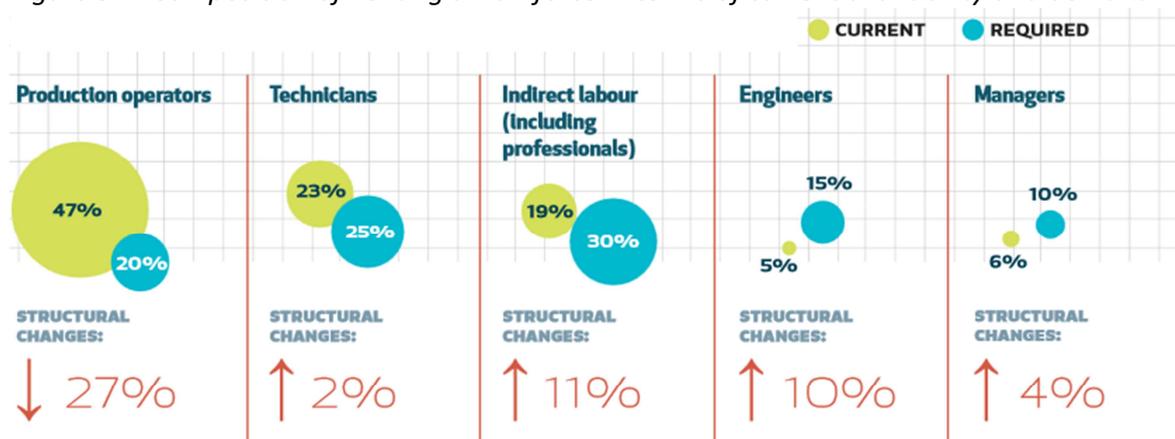
	1996	1998	2000	2002	2004	2006
Japan	4.907	5.162	5.098	5.072	5.299	5.148
Korea	2.190	2.005	2.317	3.002	3.267	4.162
Malaysia	90	154	276	295	503	367
Singapore	2.538	2.986	4.140	4.352	4.997	5.713
Taiwan	3.326	3.794	3.922	3.103	3.579	4.159

Source: Kharas et al. (2010)

Despite the great improvement in enrollment, Malaysia is still lagging behind Asian countries such as South Korea (100%) and Thailand (46%) (The World Bank, 2013). Besides the lack of enrollment, the relative level of education has dropped compared to other countries (Penang Institute, 2013a). These developments may be a reason why Malaysia is still lagging far behind in number of R&D researchers and engineers compared to competing Asian countries as is illustrated in table 3.1 above.

In figure 3.2 below, the current composition of the workforce of Penang is plotted against the required workforce. Remarkable is the 10 percent required number of engineers as compared to the current number (Penang Institute, 2011).

Figure 3.2: Composition of Penang's workforce in terms of current availability and demand.



Source: Penang Institute (2011)

Regarding the skills of the graduated people, the “Technology Roadmap” (Business Wise Consulting et

al., 2007) has revealed that MNCs have the perception that skilled people are still sufficiently available, but it is not easy to find them. In general, most of the MNCs in the E&E industry educate the graduates themselves through internal training programs. Also a collaboration of MNCs has resulted in the founding of the Penang Skill Development Centre (PSDC) in order to counter the skill shortages (PSDC, 2013).

Finally next from the low level of enrollment, the level of education and the skills of the workforce, the migration of talent from Malaysia – also referred to as “brain drain” – is still an ongoing problem. Currently 10 percent of the Malaysians with a tertiary degree migrate to an OECD (Organization for Economic Co-operation & Development) nation (Penang Institute, 2012). In order to catch up with the high-income countries it is necessary for Malaysia to retain its human capital (The World Bank, 2011). But besides retaining and attracting talent, it is also important to develop own talent. As will be discussed below, Penang has a broad selection of research and educational institutes (Kharas et al, 2010).

Research & Educational Institutes

The majority of the workforce that is involved in science and technology are working in the higher skilled industry. To improve the R&D environment of Penang it is necessary to have research institutes and educational institutes (Kuchiki & Tsuji, 2011). The manufacturing industry in Penang requires a well trained workforce. Since 2009 Penang has 22 public and 31 private institutions of higher learning (universities, training institutes and centers). The main public university is the Universiti Sains Malaysia established in 1969. It has several campuses offering medical and engineering courses (NHERI, 2010).

Besides the university the state government has established several training institutions. In 1989 the Penang Development Corporation (PDC) founded together with MNCs (National Instruments, Motorola, Intel and Hewlett-Packard) the Penang Skill Development Centre (PSDC) (as is mentioned above) in order to counter the skill shortages. Since the establishment the PSDC has become the largest learning institution in Malaysia (PSDC, 2013). In 1989 they started with 32 training programs for approximately 600 participants. By 2010, it offered over 400 training programs for 7500 participants (Athukorala, 2011). More recently new training institutions, such as Collaborative Research in Science, Engineering & Technology (CREST) in 2012 in Penang and Talentcorp in 2011 at the national level, were established. CREST is founded by 10 leading E&E companies (AMD, Agilent, Altera, Avago, Clarion, Fairchild Semiconductors, Intel, Motorola Solutions, Osram and Silterra) together with the University of Science Malaysia, Khazanah Nasional and the Northern Corridor Implementation Authority. CREST is an initiative by the E&E industry for the E&E industry to create a platform to collaborate in R&D activities (CREST, 2013). Other established training institutions in Penang are the Japan Malaysia Technical Institute (JMTI), Dreamcatcher and the MARA Training Center (NHERI, 2010).

Besides educational institutes, in order to move up the value chain and become more innovative, research institutes are significant. On the national level the Malaysian Institute of Microelectronic Systems (MIMOS), which started in 1985, operates as a R&D center in ICT innovations with over 600 researchers, scientists and engineers. The focus of MIMOS is on developing technology platforms for local industries. Hereby, MIMOS supports companies in developing technologies for products (MIMOS, 2013). On the state level of Penang the Penang Institute, formerly known as the Socio-Economic and Environmental Research Institute (SERI), established in 1997, is the state think tank. The Penang Institute researches public policies in cooperation with the state government (Penang Institute, 2013b).

Linkages between the educational & research institutes and the E&E industry can contribute to learning in order to become more innovative. Since 2007 the Division of Industry and Community Network is established within the Universiti Sains Malaysia. This division aims to create close, effective and sustainable linkages with the industries in Penang. By means of improving and intensifying existing

linkages and partnerships, and entering into new linkages this division contribute (NHERI, 2010)

Although a considerable number of supporting educational and research institutes are at hand, Hutchinson (2010) has revealed that there are many barriers for the flow of information between the institutions and the industries. It seems that mainly large established MNCs are capable to communicate with institutes. Together with the results from the “Technological Roadmap” (Business Wise Consulting et al, 2007) wherein MNCs have indicated that there is still a need for the improvement of skills that can be facilitated by the University and training institutions, Penang still has its bottlenecks regarding the educational and research institutions.

Supporting Industries in Penang

Since the arrival of the first MNCs during the 1970s the E&E industry expanded. In order to supply these MNCs a network of supporting industries began to emerge. Stamped metal components, automation equipment, jigs, machine tools and molded rubber products were among them. At the start these supporting industries were dominated by small and medium-sized enterprises (SMEs) from Japan, Singapore and Taiwan. After a period of foreign owned SMEs a group of local companies emerged. Most of the local companies were founded by former MNC employees (for instance former Intel employees established Globetronics, LKT Engineering and Unico) (Athukorola, 2011).

The supporting industries have rapidly developed since the emergence of the E&E industry in Penang. In order to fulfill the needs of the MNCs the local companies have evolved (InvestPenang, 2013b). According to Henderson and Phillips (2007) this development is exceptional. Looking back at the last two decades the local SME support industry in Penang has grown significantly. In some cases local firms have become MNCs (e.g. Globetronics and Eng Teknologi) themselves due to the development of their technological competences. This became possible due to the support of PDC and related institutions. At the national level the SMEs in the E&E industry have had no encouragement or whatsoever. Nevertheless, even with the support from state institutions, the SMEs in Malaysia have not been able to upgrade into more sophisticated operations that are necessary for the industry (Henderson & Phillips, 2007).

Institutional Environment

As is mentioned in the theoretical framework, besides resource endowments the institutional environment is part of the locational environment. At the national and state level several institutions are operating that influence the developments of the E&E industry in Penang.

Malaysia is a federation with a parliamentary democracy of thirteen states and three federal territories. At three levels – federal, state and local – the government is established. The state government has the autonomy to make decisions on the economic and social development by implementing policies and programs. However, the federal government restricts the degree of autonomy by policies and regulations of its own. At the local level authorities have certain control over local development issues, but are supportive to the state government (NHERI, 2010).

In order to perform certain tasks the federal and state governments have established several agencies through the years. The federal government has for instance set up the Malaysian Investment Development Authority (MIDA) in 1967 as a result of a World Bank initiative. MIDA is established as an investment consulting agency for the government on industry and policy issues. Since the establishment MIDA has constructed three industrial master plans. In addition, MIDA assists companies which intend to invest in Malaysia (MIDA, 2013).

At the state level the state government of Penang has established agencies for the development of Penang. In 1971 the Penang Development Corporation (PDC) was founded as the development agency to create projects for the development of the state. Currently the PDC is mainly focused on land

development in Penang (PDC, 2013). The state government has also established in 2004 a non-profit entity, InvestPenang, which is mainly focused on attracting companies to invest in Penang and sustaining business activity through continued investments. InvestPenang is important for Penang as it amongst others provides information to investors, enhances the business environment and supports the growth of existing firms (InvestPenang, 2013b).

Besides institutions at the federal, state and local level the federal government of Malaysia has in 2007 embraced a new approach to face the problems of being a middle-income country. The main focus of this project is on, so-called, regional corridors. These designated regions can profit from the labor, land and natural resources found in the hinterland. Together with the knowledge on manufacturing and network connections these regions have the potential to grow (Kharas et al, 2010).

This has resulted in the creation of the Northern Corridor Economic Region (NCER). Perak, Perlis, Kedah and Penang have been combined into a single economic region. The main goal of the NCER is to develop the region into an area that can compete on global scale and attracts foreign investment. Through the Northern Corridor Implementation Authority the NCER has powers to create and execute a development strategy (Kharas et al, 2010).

For the Northern Corridor strategy, 2 objectives are important. First, investments in significant infrastructure projects by the federal government are set up. The construction of the second bridge, the upgrading of the public transportation, housing development and sewerage treatment are amongst other investments included. Secondly the strategy focuses on the development of new areas of business, together with the expansion of existing industries. The strategy aims on value-adding in existing industries, together with the creation of new industries (Kharas et al, 2010).

With the variety of institutions operating at different levels it is expected that a large number of policies are constructed. It is unclear if the constructed policies of the institutions are tuned with each other and/or if these institutions cooperate with each other. Is for instance the constructed policy at the state level in conjunction with policies constructed by the NCER? And which policies are leading or should be leading?

Infrastructure

Since the 1970s the population and economy of Penang has grown tremendously and therefore has put pressure on its distribution and (physical and ICT) infrastructure. Currently Penang is excellent connected via land, sea and air. It has an international airport, the second largest after Kuala Lumpur, and is globally connected among others with Singapore, Thailand and Indonesia (InvestPenang, 2013a). However, its runway is still too short for handling large commercial aircrafts (Woo Wing Thye, 2013). The island of Penang is also connected via the sea. The Penang Port is the third largest container port in Malaysia (InvestPenang, 2013a). But, it lacks the depth for larger container ships to call (Woo Wing Thye, 2013). Besides the sea and the air, Penang is also connected via the road. Since 1985 the island is connected with the mainland via a 13.5km long bridge (Penang Bridge, 2013). In 2006 the federal government decided to build a second bridge in order to enhance socio-economic developments. By 2008 the construction finally commenced and is set to open in November 2013 (The Star, 2013a).

Besides the physical infrastructure, also the ICT infrastructure plays an important role for the development of Penang. A good ICT infrastructure with fast internet makes companies well connected. Unfortunately Malaysia is worldwide part of the countries, fifth from below, with the slowest desktop internet speed (Woo Wing Thye, 2013).

Livability

The way of living in Penang is harmonious, restful but lively and exciting. This lifestyle can be attractive for highly educated and creative people such as professors, doctors, engineers, artists and craftsmen.

Unfortunately, Penang is facing shortages on the human capital side at the moment. Through the “Malaysia My Second Home” project the government of Malaysia has tried to make it easier for high educated people to migrate to Penang (Kharas et al., 2010). A better quality of life contributes to increase the industries that involve skill-intensive labor. This means that a favorable social and physical environment is desired, whereby certain attributes are acquired which together define the liveability of Penang. (Kuchiki & Tsuji, 2011).

Over the past 20 years most of these attributes have declined. First of all, due to its relative smallness along with the expansion of urban and industrial areas there have been negative effects of solid waste, and water and air pollution in Penang. This has resulted in polluted rivers and coastal areas (NHERI, 2010). Secondly, Penang has a poor transportation system and people are therefore forced to choose private transportation. This has resulted in more vehicles on the road, and without any plans for managing this growth, traffic congestion has increased (Woo Wing Thye, 2013; Kharas et al, 2010). What is even more disturbing is that public services such as waste disposal and bus transportation are projects of the federal government, while the state governments clearly have a better understanding of these services within the state (Kharas et al, 2010). Third, the housing market in Penang lacks property for the middle-income population. Due to an increase of the average property price of 42 percent along with an increase of only 25 percent average household income a growing gap is the result. Third, the public transportation system is poor and lacks of accessibility. Fifthly, a safe neighborhood contributes to more livability. The total number of crimes has dropped between 2007 and 2011 with 16 percent in Malaysia (Department of Statistics, 2012a). And finally, higher skilled personnel require cultural attractions. Due to the diversity of cultures through time, the Penang state is rich on cultural heritage. Since 2008 Georgetown is part of the UNESCO world heritage site (Woo Wing Thye, 2013).

3.2 Conclusion

In this chapter all relevant conditions for upgrading are presented with an overview of the regional characteristics of Penang. Although the proportion of enrollment has grown tremendously since 2 decades, Malaysia still lags behind competitive countries. Besides, the level of education has dropped, the number of engineers is lagging behind and talent is migrating to other countries. To facilitate opportunities for higher education more than 50 public and private institutes are established. But the current conditions of these institutes have revealed that there are many impediments to fulfill the needs of all MNCs. The Universiti Sains Malaysia is the main public university that has an engineering campus. In terms of research institutes there are only a few present at the national and state level. Linkages between the institutes and the industries of Penang are only set up limited.

As for supporting industries, since the start of the E&E industry in the 1970s they have emerged in order to fulfill the requirements of the MNCs. To keep up with the developments of the MNCs the supporting industries have evolved alongside. Unfortunately they have not upgraded sufficiently in order to cope with the demands of the MNCs.

Observing the institutional environment of Penang, the diversity of institutions that are operative at the national, regional and state level is striking. Each institute constructs its own policies. It is unclear how these institutions cooperate and if the policies that are constructed at each level interfere with each other. But tensions between the institutions can cause interest entanglements, which can delay the development processes.

As is mentioned in several reports, the physical infrastructure of Penang seems to be sufficient, as it is well connected via sea, land and air. And with the construction of a second bridge Penang and plans for upgrading the sea- and airport Penang will become even more attainable. As for the ICT infrastructure Penang has to make great strides, as it has currently slow internet speed.

In order to retain and attract talent Penang’s living environment is in need of improvement when facing problems such as congestion, pollution and housing. Together with a demand for social facilities,

libraries, shopping and heritage site from young professionals a new strategy should be introduced.

In summary, the overall conditions of the regional characteristics are in need of improvement in order to fulfill the needs of the MNCs and to attract and retain talents. In next the paragraph these conditions led to certain expectations formulated in hypotheses.

3.3 Hypotheses

From the theoretical framework and the conceptual framework in the previous chapter and the regional analysis in this chapter, the following expectations are derived about MNC subsidiaries in the E&E industry in Penang. According to the scale levels used in this research, the hypotheses are divided into the industry and the subsidiary level.

Industry Level

As described above, based on its regional characteristics Penang seems to keep lagging behind other Southeast Asian regions. Especially when it comes to labor, Penang does not seem to be able to catch up with regions in countries such as Japan, Singapore and South Korea. This might be an issue for the E&E industry of Penang and the region's attempt to attract MNCs in sophisticated branches. With respect to their location strategy, these MNCs are not likely to favor Penang over other regions when they want to relocate a subsidiary with sophisticated products. Particularly as MNCs in the E&E industry require skilled labor to adapt to the rapid technological developments within the industry. At the same time Penang has to cope with the competition of emerged low-cost countries such as China and Vietnam. In light of these developments, while MNCs from other related branches refrain from entering Penang, MNCs in sophisticated are more likely to move away from Penang. These expectations result in the following hypotheses:

Hypothesis 1: Between 1994 and 2013, only MNC subsidiaries from established branches have entered the E&E industry in Penang.

Hypothesis 2: Between 1994 and 2013, MNC subsidiaries from sophisticated branches have left the E&E industry in Penang.

In essence, hypothesis 1a is nor positive nor negative for Penang. However, in such a dynamic industry as the E&E industry, the lack of entries from new branches is not an indication of overall industrial upgrading. Furthermore, hypothesis 1b has a strong negative impact on the sophistication of the composition of the E&E industry in Penang. Both hypothesis 1a and 1b combined lead to the following concluding hypothesis about the industry level in Penang:

Hypothesis 3: Between 1994 and 2013, the evolution of industry branches has revealed downgrading of the E&E industry in Penang.

Firm level

Following the theoretical framework, at the subsidiary level upgrading of functions, products and processes is subject to decision-making processes. The extent to which these decisions are in the hands of the subsidiary or its HQ depend on the subsidiary's charter, which in turn is determined by its position within the RPN of its MNC. The subsidiary's position within the RPN depends on its embeddedness within Penang and the commitment of the MNC to Penang. As the regional characteristics of Penang influences this embeddedness and commitment, the lagging behind of Penang results in the following hypotheses:

Hypothesis 4: Between 2004 and 2013, functions, products and processes within MNC subsidiaries in the E&E industry in Penang have downgraded

Hypothesis 5: Between 2004 and 2013, the charter of MNC subsidiaries in the E&E industry in Penang has decreased.

Hypothesis 6: Between 2004 and 2013, less locational commitment of MNCs in the E&E industry in Penang is caused by the degeneration of Penang's regional characteristics.

Hypothesis 7: Between 2004 and 2013, a weaker position in the RPN of MNC subsidiaries in the E&E industry in Penang is caused by less locational commitment of MNCs to Penang.

Chapter 4: Methodology

This chapter presents an overview of the methodological research decisions regarding the modes of data collection and analyzes. As is mentioned in the introduction, the aim of this research is to map the evolution of the E&E industry from 1994 to 2013 in Penang. During this designated period, MNCs enter, exit or remain in the E&E industry, thereby altering the composition of the industry.

This chapter is divided in 5 paragraphs. The first paragraph justifies the used research design in this thesis. Thereafter in the second paragraph the definition, which is used in this study, of the E&E industry is given. Paragraph three makes clear on the industry level which methods are used and which decisions are made regarding the research. In paragraph four a similar clarification is made on the firm level. Finally this chapter concludes with a discussion on any problems that have occurred during the research.

4.1 Research design

This research is derived from existing theoretical insights presented in the theoretical framework and therefore deductive in essence. The theoretical framework and its conceptual framework provide the different concepts that are helpful for explaining changes in the E&E industry. As is mentioned above the purpose of the research is to display the evolution of the E&E industry from 1994 to 2013 in Penang and to understand the mechanisms behind the processes of the evolution. A longitudinal research design makes it possible to identify changes over time (Bryman, 2012). Due to repeated intervals of the collected data an overview can be constructed of different situations of firms over time, and therefore making it possible to show changes.

Besides the observation of changes of the industry over time, this research has as its objective to understand the reasoning behind these changes. Therefore the research is executed on 2 levels. First, at the industry level to observe and map the changes of the E&E industry as a whole, and secondly on the firm level to understand the reasoning behind these changes. This dichotomy on different scales requires varied research methods. These are explained in more detail in the paragraphs on the industry and firm level.

4.2 Defining the E&E industry

According to the Malaysian Investment Development Authority (MIDA), the E&E industry in Malaysia consists of firms in four sub-sectors: (1) consumer electronics, (2) electronic components, (3) industrial electronics, and (4) electrical products (MIDA, 2013). Consumer electronics consist of LED television receivers, audiovisual products such as blue-ray players/recorders, home theater systems, mini disc, game consoles and digital cameras. Electronic components include all products and activities regarding semiconductor devices, passive components, printed circuits, substrates and connectors. Industrial electronics encompass multimedia and information technology products such as computers, computer peripherals, telecommunication products and office equipment. Electrical products involve lightings, solar related products and domestic appliances.

Although the sub-sectors of the E&E industry provided by MIDA give useful insights into the activities deployed within the E&E industry, this classification does not provide a workable definition to measure all productive activities as it is too broad. To provide guidance to countries developing classifications of their productive activities, the first International Standard Industrial Classification of All Economic Activities (ISIC) has been composed in 1948 (United Nations, 2008). It has been subsequently revised to capture changes in the economy. Ever since the original version of the classification, countries have adopted ISIC, or used ISIC to derive a national classification from it. The most recent version of the Malaysia Standard Industrial Classification (MSIC) is largely based on ISIC, revision 3 (Malaysia Department of Statistics, 2000).

MSIC provides four levels of activities, descending in order of size: divisions, groups, classes and items. While divisions are the least specific levels of activities, items are the most specific and resemble the branch level as elaborated on in the theoretical framework. According to MSIC, the E&E industry is included in the broader category D “manufacturing”. Within the manufacturing category, 5 broad divisions can be distinguished, encompassing the activities in the E&E industry based on the classification of sub-sectors provided by MIDA: manufacture of machinery and equipment; manufacture of office, accounting and computing machinery; manufacture of electrical machinery and apparatus; manufacture of radio, television and communication equipment and apparatus; and manufacture of medical, precision and optical instruments. These divisions can be further classified and coded into the relevant subdivisions at the branch level as presented in the following table (4.1).

Table 4.1: Composition of the E&E industry in branches (divisions and items).

Division:	Item:	Manufacture of:
29: Machinery and equipment	29191	Air-condition, refrigerating and ventilating machinery
	29199	Other general purpose machinery
	29220	Machine tools
	29230	Machinery for metallurgy
	29290	Other special purpose machinery
	29300	Domestic appliances
30: Office, accounting and computing machinery	30001	Office and accounting machinery
	30002	Computer and computer peripherals
31: Electrical machinery and apparatus	31100	Electrical motors, generators and transformers
	31200	Electricity distribution and control apparatus
	31301	Telecommunication cables and wires
	31302	Electric power cables and wires
	31303	Other insulated cables and wires
	31400	Accumulators, primary cells and primary batteries
	31500	Electric lamps and lighting equipment
32: Radio, television and communication equipment and apparatus	32101	Semi-conductor devices
	32102	Electronic valves and tubes and printed circuit boards
	32109	Other electronic components
	32200	Television and radio transmitters and apparatus for line telephony and telegraphy
33: Medical, precision and optical instruments	32300	Television and radio receivers, sound or video recording or reproducing apparatus
	33110	Medical and surgical equipment and orthopedic appliances
	33120	Instruments for measuring, checking, testing, navigating and other purposes
	33130	Industrial process control equipment
	33201	Optical instruments
	33202	Photographic equipment

Source: Malaysia Department of Statistics (2000), *edited*.

In this research the E&E industry is defined as the industry that entails all products mentioned in table 4.1. The table contains all products of the E&E industry, based on MSIC. The original classification is

edited in such a way that irrelevant products are excluded. All the sub-sectors as distinguished by MIDA (2013) can be found within the specified manufacturing activities.

4.3 Methods on Industry level

As is mentioned in the theoretical framework, evolution at the industry level can be explained to a large extent by dynamics in the composition of an industry. MNC subsidiaries' exits and entries both alter the composition of the industry. These entries and/or exits of subsidiaries result in the creation of new branches, while old branches may cease to exist. Since the time span of this research ranges from 1994 to 2013, this requires an inventory of all established subsidiaries, subsidiary exits and entries and their respective products from each year. All this information is collected and stored in a database. In order to explain a dynamic process like evolution, the starting point of the analysis is the composition of the E&E industry in 1994. Of all subsidiaries, the following information is required:

- Subsidiary name
- Former names of the subsidiary
- MNC name the subsidiary is part of
- Presence in Penang (between 1994 and 2013)
- Product (between 1994 and 2013)
- Contact details

4.3.1 Population

The examined population consists of all MNC subsidiaries that (have) operate(d) in the E&E industry in Penang from 1994 to 2013. An MNC is defined as a firm that has operating subsidiaries in at least 2 countries (Business dictionary, 2013). Included are subsidiaries of foreign-owned MNCs and of local MNCs that have subsidiaries outside of Malaysia. In some cases the establishment of local MNCs may be an HQ. To improve legibility, in the remainder of this thesis all HQs and subsidiaries are referred to as "MNC subsidiaries". Excluded are firms that have subsidiaries in at least 2 countries but make products that are not encompassed in the E&E industry and only have a supplying role for the E&E industry (i.e. firms producing molding or metal parts that are used in semiconductors).

4.3.1.1 Data sources

The secondary data described above is obtained from several sources. First of all, data from a previous study on all industries in Penang, including the E&E industry is used. This study analyzed all industries in Penang from 1970 to 2004. From this study relevant data is derived on MNC subsidiaries in the E&E industry in Penang from 1994 to 2004. Secondly, data is retrieved from the Malaysian Investment Development Authority (MIDA), a governmental institution with its head office in Kuala Lumpur. Besides the respective address and name of the subsidiaries in Penang, the data also include information about investment approvals from 1995 to 2012. However, this data was strictly available for MNC subsidiaries still in operation in 2011 and 2012. Thirdly, data is collected from the Japan External Trade Organization. The acquired data contains extensive information on Japanese MNC subsidiaries from 1995 to 2012 in Penang. The fourth data source for this research is InvestPenang, a non-profit organization and part of the state government of Penang. InvestPenang's website includes a directory of all firms in the E&E industry, currently present in Penang. Finally, general information is collected from firm websites for all MNC subsidiaries in the database (if available). By means of combining all data from all different data sources the database is constructed. The database can be used to display the evolution of the E&E industry, as will be explained in the paragraph on data analysis.

4.3.2 Industrial upgrading and branching

To elaborate on the concept of branching, in this paragraph industrial upgrading is operationalized by means of branching. In this research a branch is defined as an economic division of an industry, in this case the E&E industry. All firms within a branch are engaged in similar products and services. As mentioned before, the E&E industry consists of several branches and the composition of the industry is subject to change (Neffke, Henning & Boschma, 2011). Due to technological developments, the life-cycle of an industry is characterized by the emergence of new branches, while old ones cease to exist, a process also known as branching (Boschma & Frenken, 2009). Into account is taken the technological intensity of a new branch. On the other hand also existing branches may have become more sophisticated, and if possible also this is taken into account. In case the composition of the industry becomes more sophisticated than before, industry level upgrading has taken place.

By entering in the database for every year whether an MNC subsidiary is present, whereby 1 is present and 0 absent, the lifespan of each subsidiary can be displayed. The combinations of all lifespans of subsidiaries with similar products show the development of that branch. The change of the composition of all branches together show the evolution of the E&E industry between 1994 and 2013 as a whole.

4.3.3 Division of branches

With the collected data on all MNC subsidiaries from 1994 to 2013 a classification is made of branches, based on the subsidiaries' main product. Since not all products in the ISIC/MSIC classification are equally relevant for this research, while other branches are underexposed, a different classification is used to construct relevant branches to study. The Global Industry Classification Standard (GICS) is in this case of better use. This classification still required editing to construct fitting product groups for the subsidiaries in Penang. Therefore, the GICS was more a guidance than a strict classification. For identification of all relevant branches, the products of 1994 are taken as a frame of reference. From this year onwards, all new products (or product groups) result in the emergence of new branches, while pulled out products (or product groups) result in branches that cease to exist. Therefore, the composition of the E&E industry in Penang in 2013 may differ from the composition of the industry in 1994.

4.3.4 Data Analysis

With the structured database, an in-depth analysis on all relevant branches is executed, which together display the evolution of the E&E industry as a whole. For every branch a graph is derived from the database, which shows the lifespan of every MNC subsidiary and therefore also displays the lifespan of each branch from 1994 to 2013. This way, the composition of the industry and possible changes within its branches can be analyzed. Putting these changes in a perspective of global developments within the E&E industry, this gives a clear overview of the evolution of branches is described. Finally, by combining the information on all the branches, this gives an overview the evolution of the E&E industry in Penang as a whole.

4.4 Methods on firm level

In order to understand the mechanisms behind the processes of industrial up- or downgrading, it is necessary to analyze evolution on the subsidiary level. Since upgrading processes do not just result from firm exits and entries, in addition to the industry level, the subsidiary level encompasses changes within the subsidiary. Analyzing the dynamics within a subsidiary, activities within a single subsidiary become of significance since all these activities together determine the behavior of an MNC subsidiary. The dynamics can take place within the product lines, processes, and functions of a subsidiary.

4.4.1 Operationalizing concepts

In order to construct a questionnaire for interviewing, certain concepts need to be operationalized in the way they can be measured. Most of these concepts are used to identify, understand and explain up- and downgrading processes at the industry- and subsidiary level. The concepts are derived from the theoretical framework and schematically displayed in the conceptual framework. In this paragraph the way these concepts are measured in the questionnaire and during the interviews will be explained.

Functional upgrading

As described in the theoretical framework, upgrading on the subsidiary level can occur within functions, product lines and processes (as is also displayed in table 2.1: Taxonomy of firms' technological capabilities). With respect to functions, within a subsidiary a shift between functions can take place and/or the overall number of functions within a subsidiary can change. As some functions add more value than others, some functions are more sophisticated than others. If the change in functions is associated with more sophistication or more functions, functional upgrading takes place. In order to determine the level of sophistication a classification of functions is constructed, based on a classification of Dunning & Lundan (2008), in which 1 is the lowest level of sophistication and 5 the highest:

1. Production
2. Procurement of materials
3. Sales/Marketing
4. Management
5. R&D

For example, if a shift in functions from 1 (production) to 3 (sales/marketing) takes place, upgrading has occurred. Furthermore, the expansion of functions also might indicate upgrading. When a subsidiary started with 1 (production), and currently deploys functions 1 (production) and 2 (procurement of materials), functional upgrading at the subsidiary has occurred. However, the expansion of functions might also lead to downgrading. When a subsidiary started with 5 (R&D), and it is currently involved in 5 (R&D) and 3 (sales/marketing), on average the level of sophistication within the subsidiary has decreased, so overall its functions have downgraded. So since function 5 (R&D) is the most sophisticated, a subsidiary that deploys all the functions 1, 2, 3, 4 and 5 is still less sophisticated compared to a subsidiary that has only function 5.

To get a clear view of the extent to which the developments from 2003 to 2013 have actually led to functional upgrading, a functional sophistication index is constructed. For this index, each function has been assigned a unique value in accordance with its level of value-added. For example, production has been assigned a value of 1, for procurement of materials the value is 2, sales gets a value of 3, and so on. Finally, all values are summed up and subtracted by the total number of functions, resulting in the functional sophistication index. The outcome of this index is a number between 1 and 5, which should be interpreted as a grade which represents the level of functional sophistication in a region. The function of the index is represented in the formula below:

$$\text{Functional sophistication index} = \frac{\sum(X_i * V_i)}{\sum(X_i)}$$

X = subsidiary deploying function i

V = the assigned value of function i

Because currently there is no comparison with the country average or with other regions, the outcome

of the index is hard to interpret although it does give insight in whether or not the sample has experienced functional upgrading. Furthermore, since the workforce assigned to sophisticated functions can vary among the subsidiaries, this will be taken into account. Since the respondents were asked about the share of the workforce involved in R&D activities, this information will be linked to the results on functional upgrading.

Product upgrading

Just like functions, the products made within the subsidiaries may change over time. In case products become more high-end, more complex, or more specialized during this change, this might indicate product upgrading. As the interviewees were asked about changes within the product portfolio, an overview can be constructed of the products over time. In order to find out about the development of the sophistication of the product portfolio, a question is composed whereby the respondent is asked to indicate whether he or she thinks the product portfolio has changed from low-end to high-end, from high-end to low-end or whether no significant change has occurred. A similar question is composed on the complexity of the product portfolio and if the product portfolio has become more specialized or less specialized. To put product upgrading into perspective, global technological developments in the E&E industry should be taken into account. To distinguish between product upgrading that goes hand in hand with global technological progress and product-creating upgrading, the respondents were asked whether or not the products their subsidiaries produce are new for the market.

Process upgrading

Finally, upgrading does not just take place within functions and products, but also within the processes of a subsidiary. Factors that indicating process evolution can be changes in machinery and the composition of employment in the subsidiary. The share of high skilled employees, technicians, foreign employees and engineers in the total number of employees reflects the composition. The more high-skilled the workforce, the more likely the subsidiary will be able to upgrade. Furthermore, the percentage of technicians, assembly workers, engineers can give insight in the way the subsidiary operates, the in-house knowledge and upgrading possibilities. Also, the sophistication of machinery and the automation of manufacturing determine the efficiency of the production process. Subsidiaries with high levels of sophistication of machinery and high automation of the production process are likely to have a more efficient production process. However, this is in turn largely related to the functions deployed by the subsidiary. A production process presumably requires a more automated process than an R&D process would.

Embeddedness

As described in the theoretical framework, one of the factors influencing upgrading processes is the local embeddedness of an MNC subsidiary. The embeddedness of a subsidiary comprises of all its linkages with its local suppliers, the government and other firms in the region. To identify whether a subsidiary was embedded in Penang or not, the respondents were asked about local public-private partnerships (PPPs). In addition, the respondents were asked about other factors determining the embeddedness of the subsidiaries such as the number of local employees among their workforce and the quality and diversity of the local supply-base.

Regional production network and charter

The position of a subsidiary within the MNC can be a determinant for the assignment of charter from the HQ. First of all, an overview of all MNC subsidiaries in Southeast Asia is used to show their combined RPN. This gives an impression of the most important linkages between regions within the RPN. The

“mapping” of a regional production network has been executed with the use of corporate information of the MNCs from their website. Additionally, to identify changes within the RPN, the respondents were asked questions about the development of the RPN and whether or not there have been shifts between countries. To identify the subsidiary's charter and its position within the RPN, the respondents were asked questions about the subsidiary's responsibilities and decision making processes within the MNC and how these have changed over time. These were followed by questions on the competition and collaboration within the MNC with other subsidiaries, which can reveal the corporate strategy of the MNC.

Locational commitment

The local environment and other local drivers do not just influence the performance of a subsidiary, but together with the performance of other subsidiaries within the MNC's RPN also the commitment of its MNC to that region. To find out about the relation between upgrading at the subsidiary level and MNC commitment to Penang, the respondents were asked about characteristics of the region. Based on the theoretical framework, the regional characteristics were divided into eight themes: labor, technology base, infrastructure, connectivity, federal government, state government and living environment. As the supply-base is already used to measure embeddedness, this indicator is excluded with respect to MNC commitment.

First, the respondents were asked to indicate the importance of these characteristics for their subsidiary and second, they were asked to evaluate them. They could indicate the importance, ranging from 1 (very unimportant) to 5 (very important). For the evaluation, the approach was similar, with options ranging from 1 (very bad) to 5 (very good). To see if the respondents perceived the overall environment of Penang as changed over time, a question on the development of the environment over the past 5 years was included. Although the majority of the questions during the interview covered a time-span of 10 years, it was assumed that respondents were better acquainted with relatively recent changes. Finally it is important to figure out if any of the indicators has played a major role in the (lack of) upgrading of the subsidiary. Therefore a question on this matter was included in the questionnaire. It must be taken into account that the collected data is based on the perception of the respondent.

4.4.2 Survey approach

In order to learn and understand the reasoning behind the developments at the subsidiary level, interviews with key actors within the subsidiary are required. Through this method, data is collected that helps to comprehend the underlying argumentation of relevant concepts. Hence, the interpretation of the reasoning of the respondent is important (Kvale, 1996).

4.4.3 Questionnaire

To structure the interviews, a questionnaire is composed (see Appendix A). The questionnaire consists of open and multiple choice questions about the subsidiary, its MNC and the Penang region. For the respondent, these questions have to be reasonably easy to answer, while in turn the answers have to contribute to the knowledge about internal matters. A broad division of concepts is based on the theoretical framework. Although based on the theory, the subjects are discussed in a logic sequence for the respondent. This has resulted in the following order of themes:

1. General Information
2. Evolution of the subsidiary
3. Local environment and other local drivers

4. Position of the establishment within the MNC: RPN and corporate strategy
5. Future prospects

Although a face-to-face interview is preferred, in order to increase the probability of cooperation an additional online version of the questionnaire is constructed. This version served as a back-up, in case potential respondents have a tight schedule or other reasons for not cooperating with a face-to-face interview.

4.4.4 Sample

From the database discussed in the industry level, a selection is made of MNC subsidiaries. To be able to cooperate with the interviews, the selected subsidiaries had to be currently present in the E&E industry in Penang. The selection is based on relevant characteristics of the subsidiary or its MNC, such as the year of establishment of the subsidiary, the total number of expansions between 1994 and 2013, country of origin of the MNC, the number of subsidiaries of the MNC (in Asia), firm size and whether or not the MNC is considered to be a global leading firm. Besides the characteristics, an equal division of MNCs amongst branches and the size of the MNC were taken into account. In this way the selection is dispersed as evenly as possible. This has finally led to a sample of 31 MNC subsidiaries.

4.4.5 Quality of the sample

Due to difficulties of establishing contacts from MNCs within the selection, a broader selection was constructed in order to conduct sufficient interviews. This resulted in consequences for the representativeness of the sample. As previously mentioned, the first selection was based on certain attributes of the population, such as the size of the firm, the year of establishment and the number of investment approvals. With the broader selection these attributes were less taken into account. Through this the sample has become less representative for the population. At the same time this has negatively affected the external validity of the research, which describes to what extent the results can be generalized beyond the research setting.

4.4.6 Planning and conducting interviews

For the research on firm level face-to-face interviews have been conducted. In order to arrange appointments with the representatives of each encountered firm, a strategy for calling them by telephone was constructed. From the website of each MNC the general phone number of the subsidiary was gathered. Whenever the CEO or managing director was not available for an interview, there was asked for someone with sufficient knowledge of the subsidiary to have the interview with. In this way the quality and continuity of the answers have been assured. Over two months 28 interviews have been conducted and 3 were filled out through the online version of the questionnaire. Approximately 75 firms were not willing to cooperate, due to amongst others a busy schedule, the participation in other surveys and not willing to share corporate information.

Each interview was conducted at the address of the subsidiary. In general the interviews lasted between 45 and 120 minutes, depending amongst others on the schedule of the respondent. Whenever it was allowed the interview has been recorded. In order to make the respondent feel at ease the interviews have been conducted as it was a conversation.

4.4.7 Data Analysis

With the collected data from the interviews a database has been constructed in SPSS. From the questionnaire all indicators have been labeled and coded in such a way they are used for in-depth

analyzes. By the comparison of all interviews per subject the data has been analyzed and used to confirm and/or explain observations in the quantitative data.

4.5 Discussion

During the data collection and analyzes certain obstacles came to light which are discussed in this paragraph. At the industry level little information from the obtained data was available on the activities and products of all MNCs. Therefore no analyzes have been carried out covering the evolution of branches regarding the activities. At the firm level the population consist of all MNCs between 1994 and 2013, this includes all MNCs that have exited the E&E industry in Penang. Unfortunately these MNCs have been untraceable and therefore they have been left out of the research. Difficulties with establishing contacts with the selected MNCs resulted in broadening of the selection.

Chapter 5: Dynamics in the E&E industry in Penang 1994-2013

This chapter presents a macro-analysis of the E&E industry in Penang. As briefly mentioned in the previous chapter regarding the methodology of the research, the data available have imposed a few restrictions on the analysis. First, different data sources had to be linked to complete the overview of the E&E industry, which sometimes revealed conflicting results. In this case the results were verified by data on firm websites or in newspapers.

Secondly, there is a gap in the data between 2005 and 2010. Combining the 2004 and 2011 data gives insight in the subsidiaries that remained in Penang, but no exact knowledge about the year of exits. Furthermore, subsidiaries that have entered Penang after 2004 and already have left by 2011 could not be included.

Thirdly, the main products of the subsidiaries had to be determined. Information about the products was available for 1997 through 2004 and for 2011 and 2012. The missing data for the period 1994-1997 and the gap between 2004 and 2011 did not allow for a complete analysis of changes within the product groups. When comparing 2012 with 1997, product changes within subsidiaries did not seem to change very often. Furthermore, from the data available changes in the sophistication of products could not be determined. Obviously, there are examples of product changes within subsidiaries – as chapter 6 will elaborate on – which unfortunately could not be encompassed in the analysis on the industry level.

The remainder of this chapter will start with a description of the trajectory of industrialization of Penang since the beginning in 1972. Thereafter, the second paragraph will describe an analysis of the E&E industry in the period 1994-2013 by means of 4 cohorts of 5 years each. The third paragraph takes a closer look at developments within the branches of the E&E industry to illustrate the changes in the composition of the industry. Finally, this chapter ends with a fourth paragraph presenting a summary of all findings and concluding remarks.

5.1 Early establishment of the E&E industry in Penang

Before analyzing the E&E industry and developments within the industry in the period 1994-2013 in Penang, this section will elaborate on the evolution of the E&E industry in the preceding years. At the national level the federal government has realized several industrial plans spread over approximately 30 years. Within these plans the economic policy for Malaysia is pointed out. The objectives of each plan are different and therefore the plans all had another impact on the development of Malaysia as a whole as well as on the development on the state level (van Grunsven & van Westen, 2000).

In 1964 the first strategic plan for Penang was developed, known as the Munro Report. In this report, Penang was recommended for the development of an industrial area. Despite this report's early attempt to industrialize, the process was not started before the beginning of the 1970s. Due to the loss of Penang's free port status, a new report was realized which was sanctioned by the federal government, known as the Penang Master Plan. Herein the advising strategy was to focus on global markets instead of local, regional and national markets (Kharas et al, 2010).

In the period between 1970 and 1980 the federal government collaborated with the Penang state government by setting up the first Export Processing Zones, later known as Free Industrial Zones (FIZs). The PDC, closely working together with MIDA, was a key institution in attracting the first waves of MNCs (Rasiah et al., 2009). Through meetings with executive officers of leading MNCs, MIDA and PDC established an aggressive promotion strategy encouraging them to invest in Penang. MNCs who established subsidiaries within the FIZs were granted tax incentives, investment credits and import permits.

In 1972, the first FIZ was opened in Bayan Lepas in Penang. The low wages and the development of infrastructure finally led to the establishment of subsidiaries by eight MNCs in Penang between 1971

and 1975. National Semiconductors (currently known as Fairchild Semiconductors), AMD, Intel, Osram, Hewlett Packard (currently known as Agilent), Robert Bosch, Hitachi Semiconductors (currently known as Renesas) and Clarion, together known as the “Eight Samurai”, were driving the industrial transition in Penang (Athukorala, 2011). At that time they established mainly production plants, a phenomenon known as a “branch plant economy” (Watts, 1981).

The presence of these MNC subsidiaries resulted in the emergence of support industries in order to meet the MNCs' requirements: stamped metal components, molding parts, automation equipment and machine tools (Athukorala, 2011). Due to the expansion of related industries the character of the E&E industry changed into a hub-and-spoke system (Knox et al, 2003). During the 1980s Penang evolved into an export cluster with an increasing amount of branch plants in the E&E industry. In these years, the strategy of attracting key MNCs to drive economic growth referred to as exogenous implantation in the theoretical framework was fruitful for Penang. With the emergence of new branches such as the HDD branch in the late 1980s the E&E industry further expanded and Penang became known as the “Silicon Island” (Athukorala, 2011).

5.2 Recent developments in the E&E industry

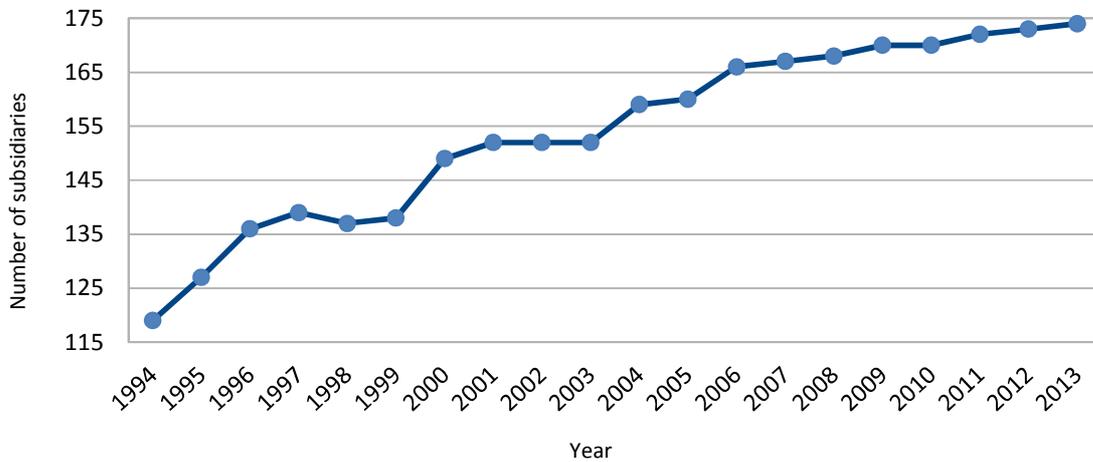
As described in the previous paragraph the industry has experienced rapid development since 1972, this section will take a closer look at more recent changes within the industry. Between 1994 and 2013 the national government has introduced several industry plans. The 6th Malaysia plan (1991-1995) emphasized on the fostering of the private sector, dominated by MNCs. The government expanded earlier set tax incentives and implemented the possibility for foreign investors to have complete ownership of assets. Within the same period the government had constructed the Second Industrial Master Plan wherein important industries (e.g. E&E industry) were identified and supported in order to retain large MNCs (MITI, 2006). In the following years the industrial plans were more focused on supporting a shift towards more high value added products and activities. Therefore the promotion of education has become a key objective in this period.

Between 2005 and 2011 Penang has contributed with an average of 8.5 percent to Malaysia's GDP. This has mainly been due to a stable manufacturing sector in Penang. In 2011 this sector provided 16 percent of Malaysia's total manufacturing output. For the GDP of Penang the manufacturing sector accounted for 49 percent. Compared with 2005 the share has dropped with approximately 5 percent (Penang Institute, 2013b). In terms of employment the E&E industry is still the largest in Penang with 32.5 percent of the total employment (The Edge, 2013).

5.3 E&E industry dynamics from 1994 onwards

The following section presents how the policies have resulted in actual MNC entries (or negatively, in exits) in Penang. As is shown in figure 5.1 below, the E&E industry in Penang consisted of 119 MNC subsidiaries in 1994. In 2013, the total amount of subsidiaries has grown to 175. Between 1994 and 1998, the amount of MNC subsidiaries increased with about 15.1 percent in 5 years to 137, although the industry has experienced a decline in 1997. The next 5 years, between 1999 and 2003, the amount of subsidiaries increased with almost 10.1 percent to 153, despite a stagnation in 2001 and 2002. In the subsequent period of 5 years, between 2003 and 2008, the increase of subsidiaries has slowed to a growth rate of 5.6 percent to a total of 168 firms. The final 5-year period, between 2009 and 2013, is characterized by an even lower growth rate; the amount of MNC subsidiaries in the industry increased with a slightly more than 2.3 percent to 175.

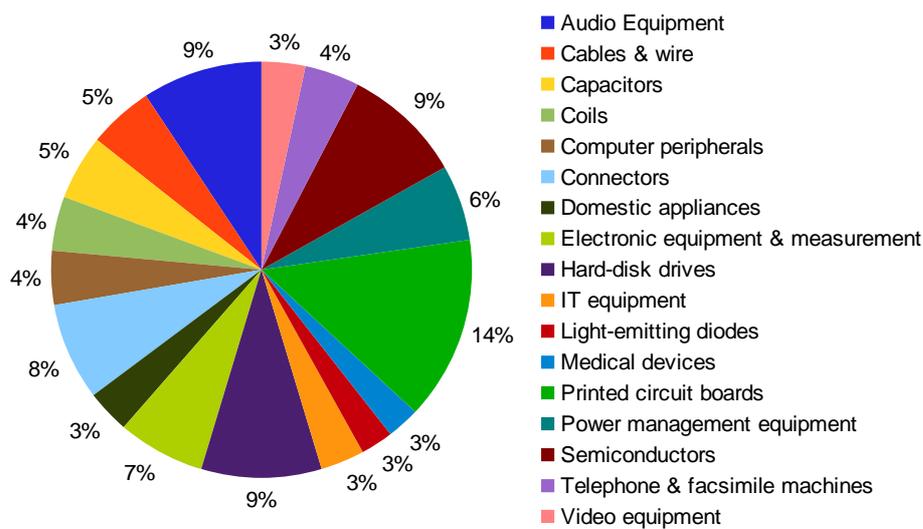
Figure 5.1: Net result of entries, exits and established MNC subsidiaries in the E&E industry in Penang between 1994 and 2013.



Source: Database 2013

From 1994 onwards, each period of 5 years shows a decreasing growth rate of the total amount of subsidiaries in the E&E industry in Penang. As figure 5.1 points out, the industry experienced a sharp decline in 1997, after which it slightly recovers in 1998 before a strong increase in 1999 and a gradual growth in 2000. In 2001 and 2002 this growth stagnates. Since 2003, the amount of subsidiaries increases again, although the growth of the industry flattens out from 2006 onwards. To take a closer look at what has happened in these 20 years, figure 5.2 gives an overview of the composition of the E&E industry in Penang in 1994. It is important to notice that where figure 5.1 represents the amount of MNC subsidiaries in absolute numbers, figure 5.2 shows the share of each branch (based on the amount of MNC subsidiaries) in the industry in 1994.

Figure 5.2: Composition the E&E industry in Penang in 1994.



Source: Database 2013

The composition of the E&E industry as displayed in figure 5.2 is a categorization based on the main products produced by the MNC subsidiaries in 1994. It shows that the primary branch of the E&E industry in Penang, with a share of 14 percent, consists of subsidiaries manufacturing Printed Circuit Boards (PCBs). The second largest branches, all account for a share in the industry of 9 percent and consist of MNC subsidiaries manufacturing audio equipment, semiconductors and HDDs. The fourth branch, with an industry share of 8 percent, encompasses MNC subsidiaries manufacturing connectors. MNC subsidiaries manufacturing electronic instruments & measurement equipment (EI&ME) and power management equipment, respectively take account for 7 and 6 percent of the industry. The remaining branches take account for a share ranging from 5 to 3 percent. These branches include manufacturers of cables & wires, capacitors, coils, telephones & facsimile machines, video equipment, computer peripherals, domestic appliances, IT equipment, LEDs and medical devices.

5.4 Dynamics E&E industry between 1994 and 2013

5.4.1 Between 1994 and 1998

As described above, the E&E industry changed quite rapidly between 1994 and 1998 as the total amount of subsidiaries increased with about 15 percent. Taking a closer look at this growth, the changes result from 28 subsidiary entries and 9 exits. From these entries and exits, 2 subsidiaries were established and already shut down in the same period. Looking at the nature of the exits, three of the 9 subsidiaries were manufacturers of audio equipment, 2 were involved in the manufacture of EI&ME, while the remainder were manufacturers of HDDs, cables & wires, semiconductors and computer peripherals.

The entries in this period consist of 4 subsidiaries in audio equipment and 4 in semiconductors, 3 in HDDs, 3 in EI&ME, 3 in PCBs, 2 in computer peripherals. Furthermore manufacturers of coils, domestic appliances, IT equipment and power measurement equipment have entered Penang. From 1994 to 1998, 2 branches have emerged that did not exist in the preceding years: 4 firms involved in the manufacture of computer hardware and 2 firms manufacturing solid-state drives (SSDs) entered the region. Although not many subsidiaries are involved in the production of computer hardware and SSDs, the products in these branches differ significantly from the ones in established branches.

As previously mentioned, in the 1990s MNCs started moving their productive activities to low-cost countries and away from Penang. Furthermore, in 1997, Southeast Asia experienced what is currently referred to as the Asian Crisis. With both the crisis and MNCs moving away, this was a tumultuous period for Penang. In this period, the most heavily affected of all branches was the audio equipment branch. However, as not all the effects of the Asian crisis might have been immediate, it may have had consequences for subsequent periods.

5.4.2 Between 1999 and 2003

Although the growth of the E&E industry from 1999 to 2004 declined compared to the preceding period, the industry experienced quite some activity regarding subsidiary exits and entries. In this period, 37 MNC subsidiaries entered Penang, while 22 subsidiaries left the region. Among the exiting subsidiaries, 3 were capacitor manufacturers, 2 were audio equipment manufacturers, 2 were EI&ME manufacturers, 2 were PCB manufacturers and 2 were power equipment manufacturers. Other branches experiencing exits included manufacturers of coils, computer peripherals, connectors, LEDs and telephone & facsimile machines. The largest setback in this period however was for the HDD branch, which declined with no less than 7 MNC subsidiaries from 13 to 7 subsidiaries (Kingston entered the region in this period).

In 1999 through 2004, the major entries occurred in the following branches: cables & wires (4 entries), computer peripherals (4 entries), EI&ME (4 entries), IT equipment (4 entries), LEDs (4 entries) and PCBs (6 entries). Other branches experiencing 2 or less entries included manufacturers of audio equipment, capacitors, computer hardware, domestic appliances, HDDs, power management

equipment, telephone & facsimile machines and video products. As a result of the entries and exits, in 2003 the computer hardware branch consists of 5 subsidiaries. The SSD branch remains very small with 2 subsidiaries. Most subsidiaries are still involved in manufacturing PCBs.

The most surprising change in this period occurred within the HDD branch, which declined with more than 50 percent. MNCs in the HDD branch might have been severely affected by the aftermath of the Asian Crisis in 1997. Therefore, more cost-effective regions in emerging low-cost countries such as China and Vietnam, might have been more attractive for labor-intensive production activities, especially since wages have risen in Penang over the past decades. To a certain extent the exits in other branches may have been affected by the aftermath of the crisis, although the consequences seem to have been less dramatic than for MNC subsidiaries in the HDD branch.

5.4.3 Between 2004 and 2008

In the third period, between 2004 and 2008, the growth rate of the E&E industry in Penang further declined, this time reflected by a low amount of entries and exits. As 21 MNC subsidiaries entered Penang, 6 subsidiaries left the region. From the exits, the subsidiaries were involved in manufacturing audio equipment, EI&ME, PCBs, semiconductors and telephone & facsimile machines.

The major entries occurred within the PCBs (4 entries), semiconductors (4 entries) and SSDs (3 entries). Although overall growth in the SSD branch is still slightly more modest compared to the other 2 branches, in this period the branch more than doubled from 2 subsidiaries to 5 subsidiaries. Other branches experiencing 2 or less entries were manufacturers of audio equipment, cables & wires, capacitors, coils, domestic appliances, EI&ME, LEDs and telephone & facsimile machines.

In this period a new crisis was looming. The financial crisis in 2008 left the US and European markets struggling. Although the crisis and the subsequent recession first seemed to remain insulated from the rest of the world, the financial problems became global, affecting emerging economies like Malaysia (Kharas et al, 2010). However, since the crisis did not set off before the end of 2008, for the E&E industry in Penang this period would have been too premature to have consequences.

5.4.4 Between 2009 and 2013

Although the E&E industry in Penang in the last period still increased in terms of total amount of MNC subsidiaries, the growth has been stagnating. The most recent period, between 2009 and 2013, is the least turbulent period of the last 20 years for the E&E industry in Penang. The industry experienced just 10 entries and 5 exits. The subsidiaries that left Penang consisted of manufacturers of cables & wire harness, computer peripherals, domestic appliances, HDDs and PCBs. With the entry of 5 subsidiaries, most of the entries in this period are LED manufacturers. Furthermore, 2 SSD manufacturers entered the region. The entries in the other branches included manufacturers of audio equipment, EI&ME, medical devices and PCBs.

In the period 2009-2013, the financial crisis became a global issue. Although the problems started in the US and Europe, other regions quickly became affected by decreasing demand and a downturn in international trade. The Malaysian economy was severely affected by adverse developments in international trade as world trade in manufacturing also declined (Kharas et al, 2010). For the E&E industry in Penang, the problems caused by the crisis have resulted in reserved investment behavior rather than in an overall decline of the industry. Unmistakably, the growth of the industry has stagnated, but this was more due to a lack of new investments than that it was accompanied by a large amount of MNC subsidiary exits.

5.4.5 Dynamics between branches

All entries and exits in the past 2 decades have resulted in a different composition of the E&E industry in 2013 compared to the composition of the industry in 1994. However, overall, the composition of the

E&E industry in 2013 has changed marginally compared to 1994. The major branch in amount of subsidiaries in Penang in 1994, the PCB branch, is still the largest branch in 2013. Furthermore, most branches in 2013 already existed in 1994. Nonetheless, noteworthy is the emergence of 2 branches that did not yet exist in 1994: the computer hardware and the SSD branch. Especially in the last period, when overall growth of the E&E industry stagnated, the SSD and LED branches still experienced growth. However, overall these branches remained quite small. In the last 2 decades, the HDD branch has declined from a dominant branch in the E&E industry to a branch of minor importance, although the most important leading MNCs in this branch, Seagate and Western Digital, are both still present in Penang.

By putting the developments of the past 2 decades into historical perspective, the decline of the HDD branch and the emergence of the SSD and LED branches is remarkable, but not even that surprising. Initially, MNCs in the semiconductor branch fueled the development the E&E industry in Penang, after which other related branches entered the region. Based on the theory on branching out processes as described in the theoretical framework and in light of the strong technological relatedness of SSDs and LEDs to semiconductors, it seemed a matter of time before MNCs in these branches would enter the Penang. Although the HDD branch has been an important branch for a little less than 3 decades, technologically HDDs are less related to semiconductors than SSDs and LEDs. With the emergence of SSDs and the expansion of LEDs, the composition of the E&E industry in Penang has become more sophisticated. Both SSDs and LEDs can be seen as substitutes with more advanced technologies for HDDs and light-bulbs respectively.

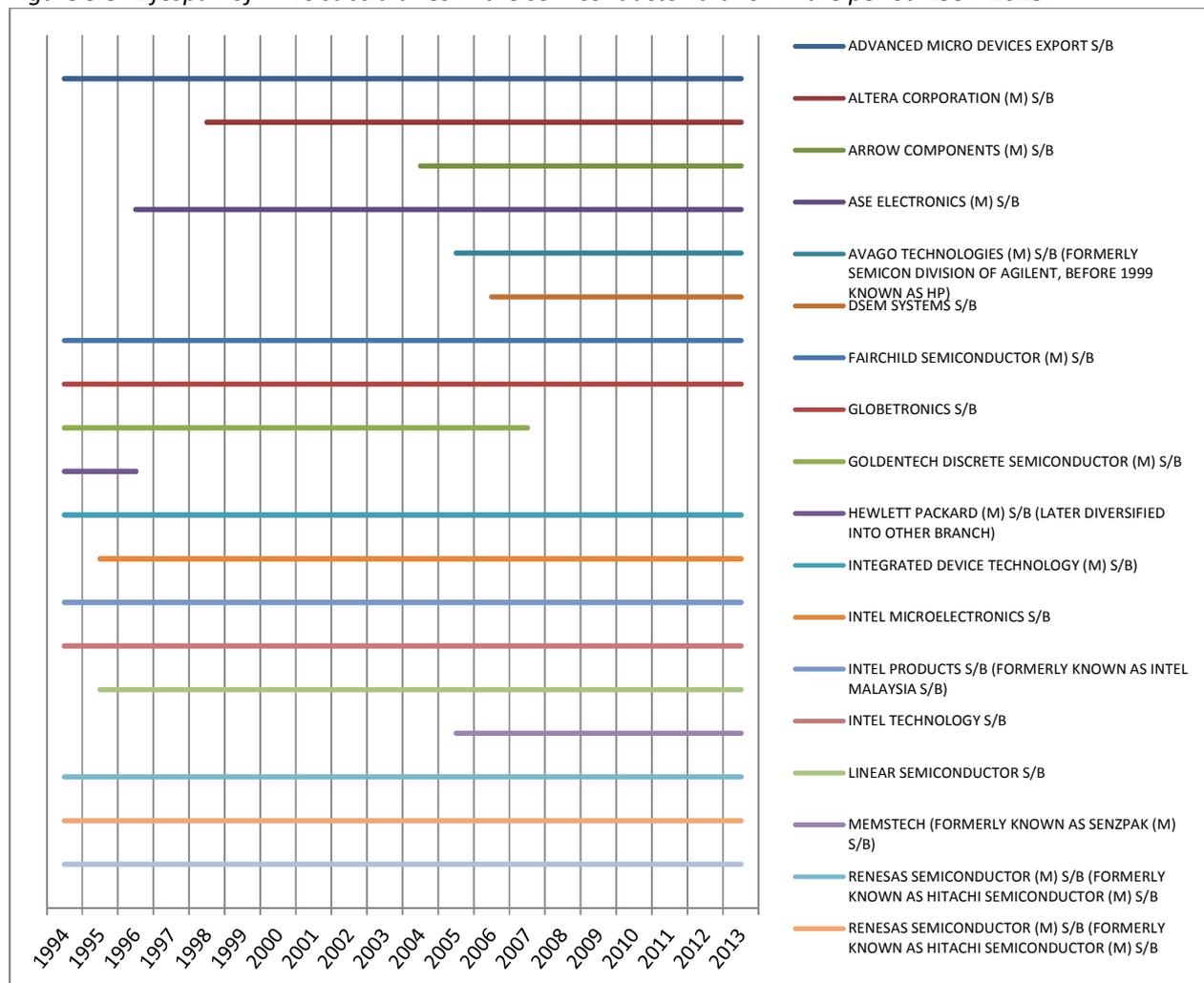
To get better insight in how the semiconductor, LED, SSD, HDD and the other branches in the E&E industry have changed in the past 20 years, the next section describes the developments within the branches of the E&E industry in more detail.

5.3 Intra-branch development

5.3.1 Semiconductors

As is described in the industrialization process of Penang, the semiconductor branch first came to Penang in 1972. Since then, global leading firms such as Fairchild Semiconductor, Hitachi Semiconductor (currently known as Renesas), AMD, Siemens Semiconductors (later ventured into LEDs as Osram), Texas Instruments and Intel. In the subsequent years, the semiconductor branch played a major role in the emergence of the E&E industry in Penang (Rasiah, 2010). Between 1972 and 1994 the branch has proven to be very stable, although Texas Instruments had already left Penang by 1994. Figure 5.3 below presents a complete overview of the established MNC subsidiaries, entries and exits in the semiconductor branch in Penang between 1994 and 2013.

Figure 5.3: Lifespan of MNC subsidiaries in the semiconductor branch in the period 1994-2013.



Source: Database 2013

Figure (5.3) shows that the semiconductor branch has experienced mostly stable growth between 1994 and 2013. In 1994 the entire branch consisted of 11 subsidiaries, while in 2013 the branch has expanded to 17 subsidiaries. In 20 years 2 MNC subsidiaries left Penang, while 8 entered the region. It has to be

noted however, that from these exits, one of them was Hewlett Packard (currently known as Agilent). The branch exit of Agilent did not result from a shutdown of their Penang operations, but to a shift in focus in 1997 from semiconductors towards EI&ME (Agilent Interview Gooi, 2013). Although not its core business, Agilent remained a manufacturer of semiconductors until 2005 when the semiconductor division spun-off as Avago Technologies, now a leading semiconductor firm itself (Agilent, 2013; Avago, 2013).

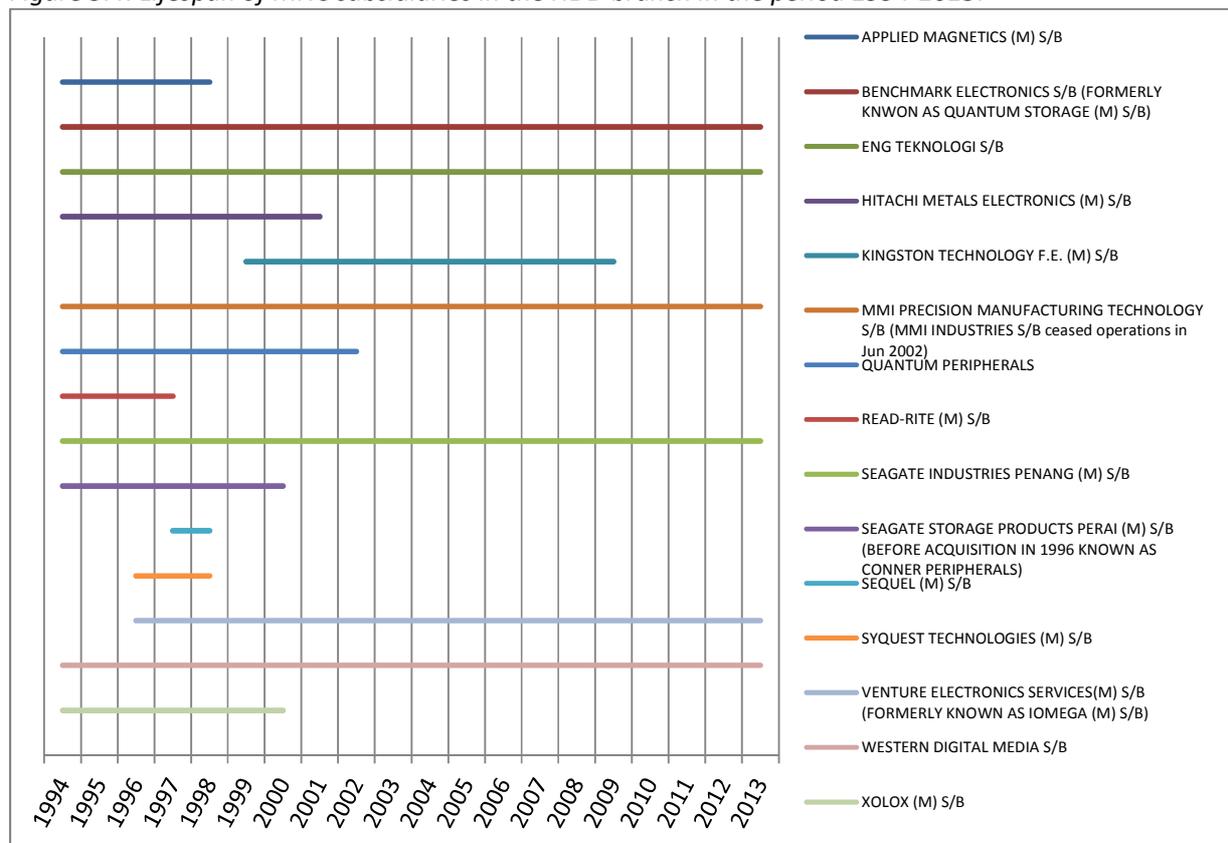
The fact that in a period of 20 years just 2 subsidiaries this branch left Penang gives an impression of the stable character of the semiconductor branch. With respect to a declining global market for PCs and laptops since 2010 this may seem surprising (Bloomberg, 2013a). Within the semiconductor branch in Penang however, Intel and AMD are the only 2 firms focusing on this market segment. And while the latter has been struggling, the former is keeping its margins high while diversifying into other market segments as despite a declining market PCs and laptops the market for mobile devices and embedded systems is expanding rapidly (Bloomberg, 2013a; Gartner, 2013; AMD Interview Yoo, 2013).

The diverse applicability of its products is characteristic for the semiconductor branch. Being a technology enabler, developments in the semiconductor branch have an impact on developments in related branches. Newly applied technologies, downscaling processes and price cuts have made it possible for new products to emerge. Furthermore, MNCs in the semiconductor branch demand a flexible and diverse supply base attracting small and medium-size firms. Besides suppliers, the wide application of semiconductors in related branches has drawn firms from these branches to Penang as well (Rasiah, 2010). Finally, MNCs in the semiconductor branch characteristically initiate spin-offs. In essence, the global leading semiconductor firms are all spin-offs from Fairchild. As for Penang, the establishment of Fairchild and Intel have initiated the spin-offs of firms such as Dynacraft (a major supplier) and Globetronics (now a large semiconductor firm in itself) (Rasiah, 2010).

5.3.2 Hard-disk drives

The HDD branch consists of MNC subsidiaries involved in manufacturing HDDs and related products. HDDs are mostly used in personal computers (PCs) and laptops. The HDD branch first came to Penang in 1988, demarcated by the entry of Maxtor and Conner Peripherals (in 1991 both acquired by Read-Rite) (Haggard et al., 1998; Readrite, 2013). Between 1988 and 1994, several other leading MNCs have relocated their production of HDDs to Penang, such as Applied Magnetics, Read-Rite, Quantum Peripherals, Seagate, CDC Imprimis (in 1989 acquired by Seagate), Lite-On and Komag (currently known as Western Ditigal). Figure 5.4 presents a complete overview of the established MNC subsidiaries, entries and exits in the HDD branch in Penang between 1994 and 2013

Figure 5.4: Lifespan of MNC subsidiaries in the HDD branch in the period 1994-2013.



Source: Database 2013

As is shown in the figure (5.4) above, the HDD branch in Penang between 1994 and 2013 can be characterized by quite a few exits. As mentioned in the analysis of the E&E industry above, the HDD branch consisted of 11 MNC subsidiaries in 1994, while in 2013 – 4 entries and 9 exits later – the total amount of subsidiaries had declined to 6. The HDD branch reached its peak in 1997 when Sequel came to Penang and right after Iomega (currently known as Venture) and Syquest Technologies entered the industry. After this peak, Read-Rite ceased operations in Penang in 1998. In 1999, the entry of Syquest Technologies and Sequel had not proved to be successful and together with Applied Magnetics their subsidiaries left Penang. Although Kingston entered the region in that same year, their departure initiated the first deterioration of the HDD branch in Penang.

The same year that Xolox left Penang, Seagate decided to close down its assembly plant in

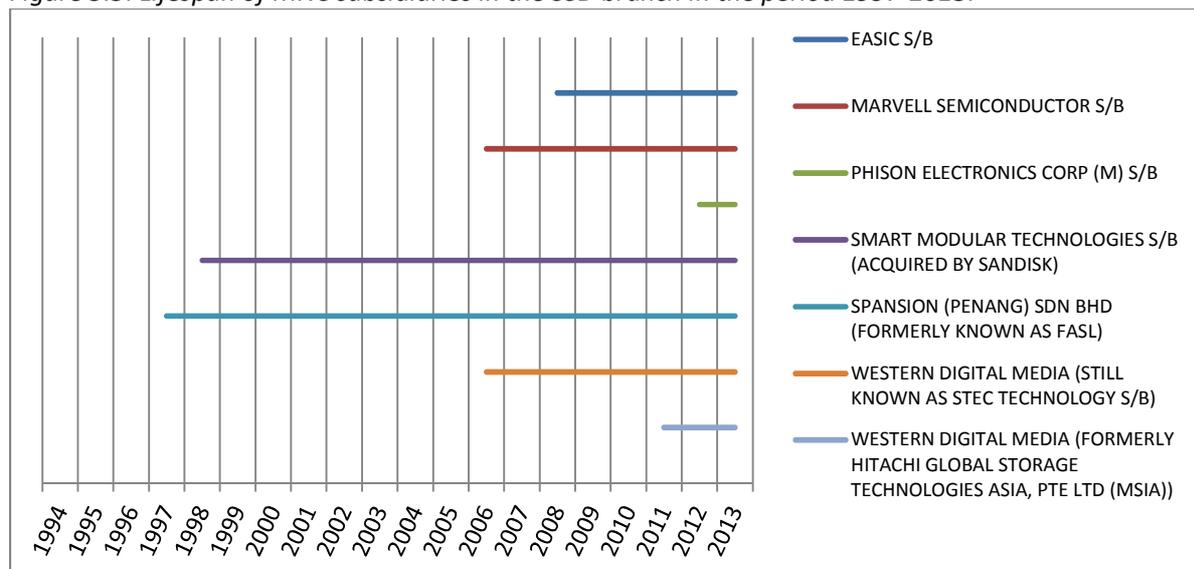
Penang in 2001 as a result of a strategy to reduce its production costs (Wallstreet Journal, 2001). At that time, Seagate had grown out to one of the major leading firms in the global HDD market together with Western Digital. After the shutdown of the assembly plant, Seagate still maintained operations in Penang. In 2003 the HDD branch in Penang received yet another setback as a result of the relocation of Hitachi Metals and the shutdown of Quantum Peripherals. From 2003 onwards there are no further mutations until the departure of yet another leading firm, Kingston, in 2009. From 2010 onwards, the HDD branch has remained stable, although compared to its peak in 1997 the branch had declined by more than 50 percent in 2013.

The downturn in the HDD branch in Penang coincided in accordance with global developments in the branch in the same period. While the technology for HDD matured rapidly, the margins have narrowed and the market steadily became saturated. The declining market for PCs and laptops since 2010 and emerging demand for tablets and smart-phones were accompanied by a decline in a demand for HDD, which are not used in tablets and smart-phones (Bloomberg, 2013a; Gartner, 2013). This has presented the established market leaders in the HDD branch with challenges for the expansion of their business and even maintaining their market share. One of the strategies of these leading MNCs is to diversify in the SSD branch, as will be elaborated on in the next section.

5.3.3 Solid-state drives

MNC subsidiaries manufacturing SSDs form the newest branch within the E&E industry in Penang, which isn't that surprising as this segment is still quite young globally. The branch emerged in Penang in 1997 with the establishment of the first MNC subsidiary, Spansion (Spansion, 2013). MNC subsidiaries in the SSD branch focus on the manufacture of SSDs and related products. Initially, SSDs were primarily implemented in supercomputers and rarely used for other purposes because of their high price. Later, they were used as HDD supplements by the military and aerospace industries. As they became more affordable, SSDs were increasingly used in PCs and laptops, because of their high performance compared to traditional HDDs. Currently, SSDs are most widely used in smart-phones, tablets and enterprise servers. Because the branch emerged from 1997 onwards, figure 5.5 below displays the entries of MNC subsidiaries in the SSD branch in Penang between 1997 and 2013.

Figure 5.5: Lifespan of MNC subsidiaries in the SSD branch in the period 1997-2013.



Source: Database 2013

As the figure (5.5) shows, the SSD branch in Penang emerged with the establishment of Spansion in 1997 and SMART Modular in 1998. Although the size of these firms can hardly be compared with HDD giants Seagate and Western Digital, Spansion is a global leader in flash-based memory solutions and SMART Modular is a technology leader in design and development of high capacity SSDs (SmartModular, 2013; Spansion, 2013). After 8 years of silence, in 2006 Marvell came to Penang, at the same time that sTec (in 2013 acquired by the HGST division of Western Digital) established its first overseas subsidiary. As Marvell is an industry leader in SSD-controllers, sTec aims primarily on enterprise SSDs. After the entry of eAsic in 2008, HGST (in 2012 acquired by Western Digital) came to Penang in 2011 with its wide range consumer SSDs. The most recent entry in the SSD branch in Penang is the establishment of an overseas research center by Phison Electronics in 2012 (The Star, 2012a).

Besides new entries and exits in the SSD branch, firms conventionally involved in the manufacture of HDDs have moved towards producing SSDs as is shown in figure 5.5 by Western Digital's wholly owned subsidiaries sTec and HGST. While Western Digital has diversified into SSDs according to figure 5.5, it must be noted that Seagate did the same. The absence of Seagate in figure 5.5 of the SSD branch is because Seagate has been shifting towards SSDs internally since 2006 when the firm started shipping its first solid-state hybrid drive (Seagate, 2006). In 2009, Seagate introduced its first SSD for the enterprise market and in 2013 it introduced its first SSD for the consumer market (Seagate, 2009; Seagate, 2013). In the meantime, Western Digital had a similar business strategy to venture into SSDs, but rather by means of acquisitions than by internal business strategy changes.

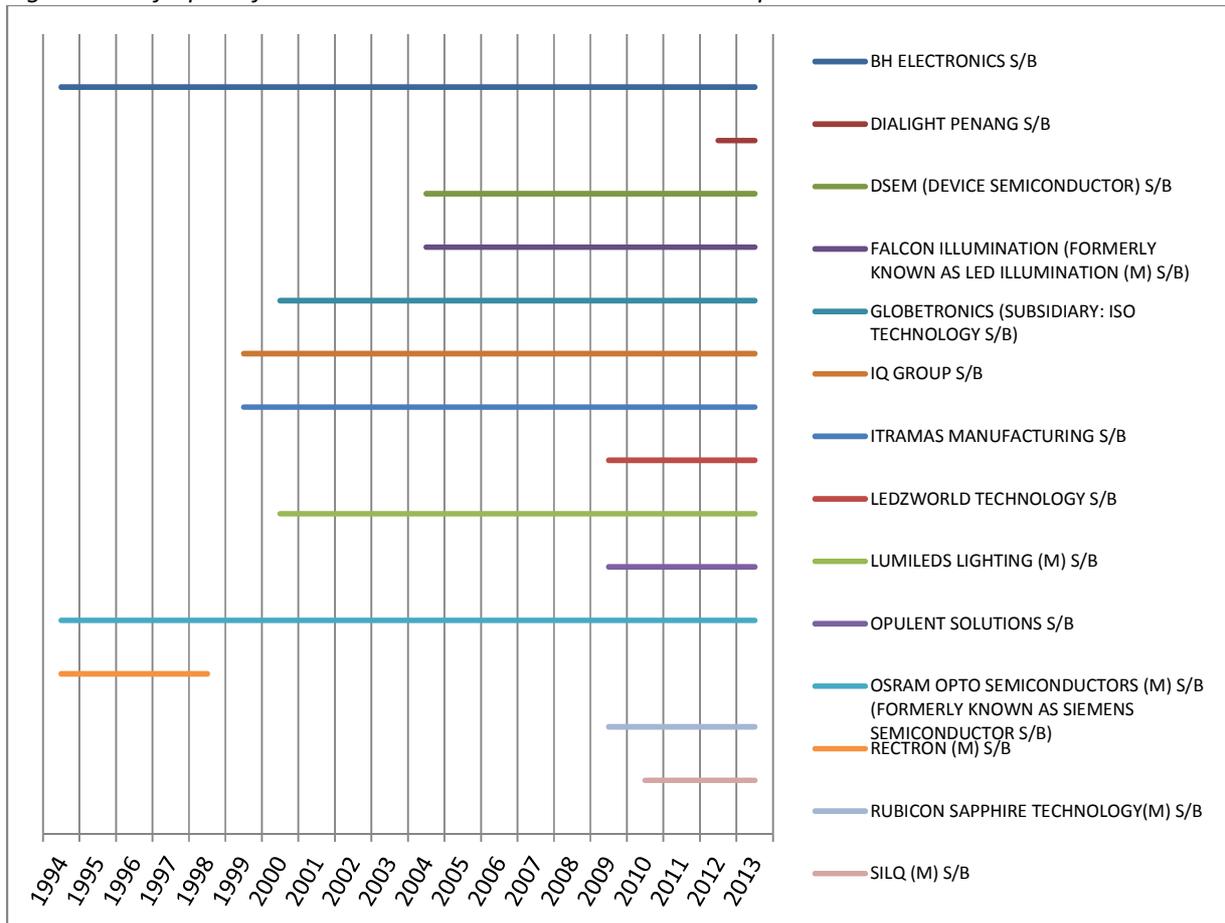
With respect to global developments such as a declining market for PCs and laptops and emerging demand for smart-phones and tablets, the developments in the SSD branch in Penang reflect these global changes to some extent. Leading firms in the matured HDD branch seek a “piece of the pie” of the rapidly emerging SSD branch. As the conventional HDD MNCs largely depend on expertise regarding HDD storage, an increasingly common strategy of these is to acquire (young) SSD firms that already have knowledge (usually by means of patents) and expertise for SSD storage solutions. However, despite the emergence of the SSD branch from 1997 onwards, the amount of MNC subsidiaries involved in SSDs entering Penang did not cover the amount of exits in the HDD branch.

Because SSDs have no moving mechanical parts, they have considerable advantages compared to HDDs. SSDs are more reliable, have lower latency and access time and they can be very small and light. Based on storage capacity, SSDs are still more expensive than HDDs, although they have become more affordable. Not only by lowering production costs SSDs have become more sophisticated. Issues such as data-loss on the long term have largely been overcome and storage capacity has increased tremendously. Although the technology behind HDDs is more mature, HDDs are already increasingly replaced by SSDs.

5.3.4 Light-emitting diodes

Although the technology for producing LEDs exists for quite some time, the wide use of LEDs in everyday life applications is a phenomenon of the past 20 years. The LED industry has grown significantly by the implementation of LEDs in mobile handsets, laptops, LCD televisions, automotive, aviation and general lighting (Athukorola, 2011). Accordingly, the LED branch is, just like the SSD branch, relatively young in Penang. However, the roots of the LED branch actually go back to the establishment of the first semiconductor firms when Siemens Semiconductors (currently known as Osram) came to Penang in 1972 (LEDInside, 2013). Now, Penang has become Osram's largest manufacturing site outside Germany and providing global R&D operations. The subsidiaries of other major MNCs later came to Penang, as figure 5.6 below shows.

Figure 5.6: Lifespan of MNC subsidiaries in the LED branch in the period 1994-2013.



Source: Database 2013

Figure 5.6 gives an overview of the developments within the LED branch in Penang between 1994 and 2013. It shows that in 20 years, just one MNC subsidiary, Rectron, left the industry in 1999. That same year, IQ Group was established and Itramas entered Penang. In 2000, Globetronics ventured from semiconductors into LED production, while a global leading firm, Lumileds (since Philips' acquisition of Agilent's share known as Philips Lumileds), opened an assembly and testing plant in Penang. Another six years later, in 2006, Falcon Illumination (formerly LED Illumination) and Device Semiconductor came to Penang. The next large investment boost for the Penang LED branch came in 2009, when Rubicon Sapphire Technologies, Opulent Solutions and Ledzworld Technologies started operations after which in 2010, Silq (a joint venture of IQ Group and Semileds) opened its doors. The most recent foreign investment in the Penang LED branch came from Dialight in 2012 as a support for the firm's growth strategy in Asia (Reuters, 2012; The Star, 2012b).

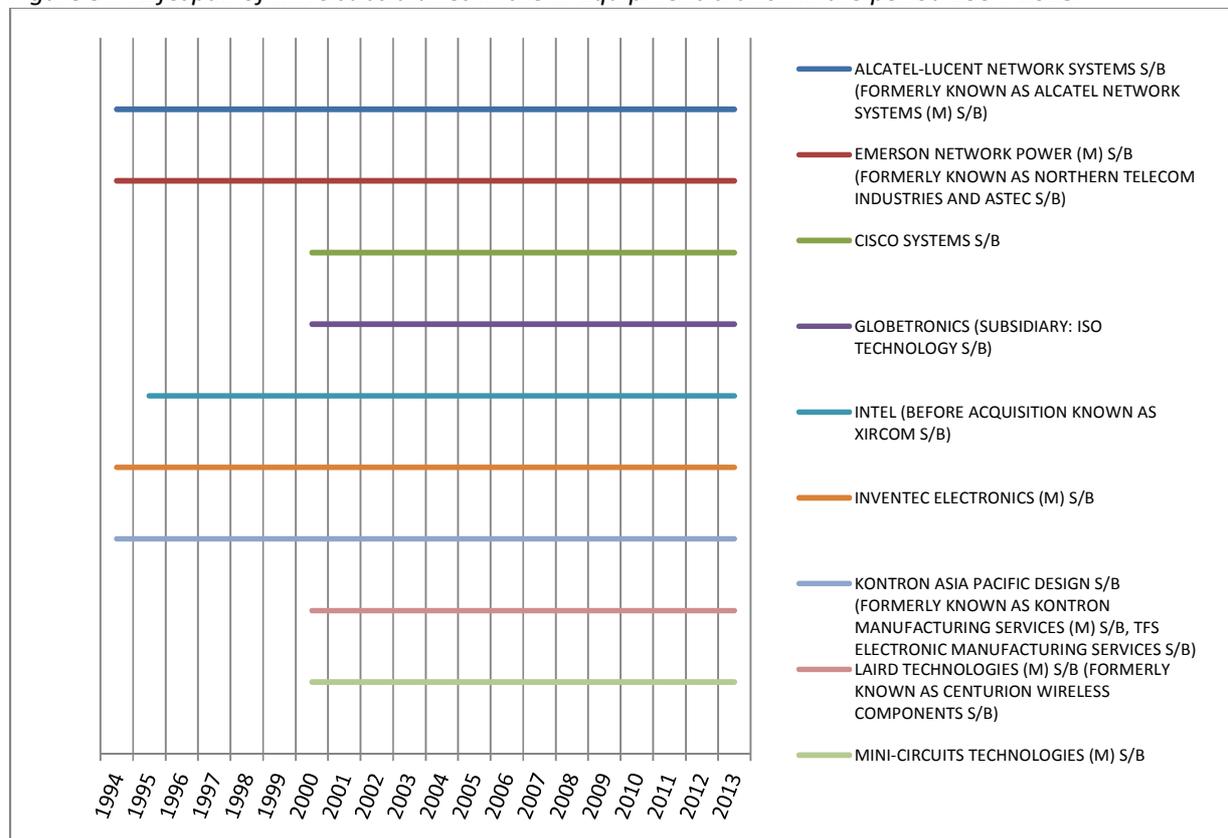
Throughout the years, LEDs have become more sophisticated. As materials became more advanced, there have been several technological breakthroughs which made not just red LEDs, but also other colors widely available. Light output increased and LEDs have become more efficient. In Penang, Osram started with the production of traditional light-bulbs, but currently the Penang subsidiary is strictly involved in LEDs. It is Osram's only facility outside Germany engaged in wafer production for LEDs and R&D besides manufacturing.

5.3.5 IT equipment

The IT equipment branch consists of networking equipment such as routers and servers. With respect to servers, there is a slight overlap with the HDD and SSD branch as these products are often used in network-attached storage (NAS) systems and NAS and servers are substitutes (AnandTech, 2013). However, following the definition presented in chapter 4, NAS would be encompassed in the HDD or SSD branch. Nonetheless, the overlap does indicate interrelatedness between the branches within the E&E industry. Furthermore, as illustrated by the move from HDDs to SSDs, MNCs seem to diversify into related branches. For instance, Cisco Systems, known for its servers and routers, is moving towards the manufacture of SSDs through the acquisition of Whiptail, while HDD giant Western Digital produces NAS (Bloomberg, 2013b).

The first MNC subsidiary manufacturing IT equipment in Penang was Northern Telecom (later known as Astec, now a subsidiary of Emerson Network Power). Other leading MNCs that came to Penang before 1994 are Alcatel (currently known as Alcatel-Lucent), Inventec and Kontron. Figure 5.7 below shows the development of the IT equipment branch between 1994 and 2013.

Figure 5.7: Lifespan of MNC subsidiaries in the IT Equipment branch in the period 1994-2013.



Source: Database 2013

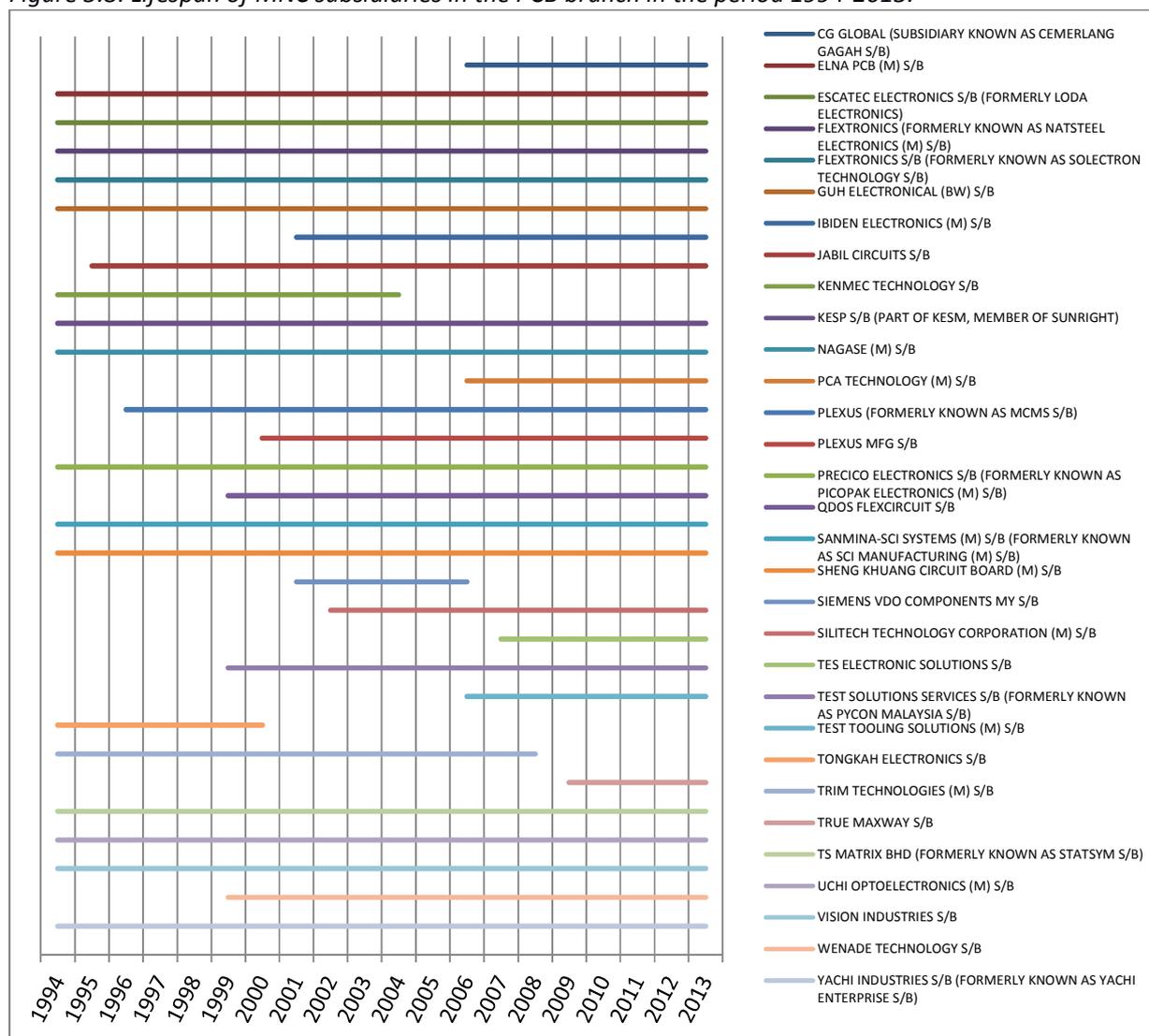
Between 1994 and 2013, the IT equipment branch has expanded from 4 MNC subsidiaries to 9, resulting from 5 entries and no exits. As figure 5.7 illustrates, the first new entry was by Xircom (later acquired by Intel) in 1995. However, the major growth in the IT equipment branch happened in 2000, when Cisco Systems, ISO Technologies (a Globetronics subsidiary), Laird Technologies and Mini-Circuits Technologies all came to Penang. After 2000, the IT equipment branch in Penang remained stable as no new MNC

subsidiaries entered the region.

5.3.6 Printed circuit boards

In contrast with the other branches discussed above, PCBs are not put on the market as final products, but they rather support and connect electronic components. PCBs can range from single sided to more advanced multi-layer PCBs. As PCBs are commonly used in electronic products, the PCB branch can be characterized as a supporting branch for the other branches in the E&E industry. Since they do not produce a final product, many PCB manufacturers are partly contract manufacturers (or original equipment manufacturers) for MNCs. However, many of these contract manufacturers have grown out to become MNCs themselves. Some of these MNCs even have become global leading firms such as Flextronics, Ibsiden, Jabil, Plexus and Sanmina-SCI. As figure 5.8 below illustrates, Flextronics and Sanmina-SCI were already present in Penang in 1994.

Figure 5.8: Lifespan of MNC subsidiaries in the PCB branch in the period 1994-2013.



Source: Database 2013

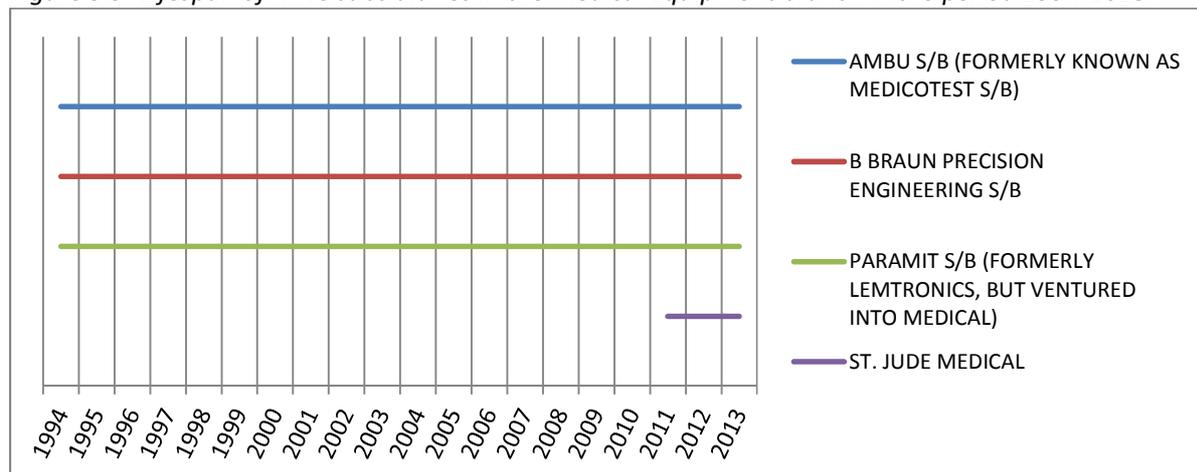
Figure 5.8 shows that the PCB branch is considerably larger than the other branches in the Penang E&E industry. The supportive character of this branch and the wide application of PCBs in other electronic (and electrical) products may be underlying to the fact that the PCB branch is that dominant within the E&E industry in Penang. Between 1994 and 2013, 14 MNC subsidiaries entered Penang, while 4 left the region. The most mutations took place between 1994 and 2006.

In 1995 and 1996, the PCB branch experienced 2 major entries of Jabil Circuits and Plexus respectively. In 1999, Qdos Flexcircuit, Pycon (currently known as Test Solutions Services) and Wenade Technology entered Penang. Another subsidiary of Plexus came to Penang in 2000, followed by the entry of Ibiden Electronics and Siemens VDO Components in 2001. That same year, Tongkah Electronics shut down its operations in Penang. In 2002, Silitech entered the region. In 2005 Kenmec Technology left, after which CG Global, PCA Technology and Test Tooling Solutions entered Penang in 2006. In 2007 the departure of Siemens VDO Components was substituted by the entry of TES Electronic. In the period 2007-2013, the PCB branch only changed in 2009, when Trim Technologies left and True Maxway came to Penang.

5.3.7 Medical Equipment

The medical equipment branch consists of MNC subsidiaries that are involved in the manufacturing of electronic devices that are used in the health-care, such as electrodes and pacemakers. In 1994, the medical equipment branch was the smallest branch (see figure 5.9) of the E&E industry in Penang with 3 MNC subsidiaries. The branch remained this size until 2011, when US-based St. Jude Medical came to Penang. In 2013, Haemonetics Corporation has announced the establishment of a manufacturing facility, but this subsidiary is expected to open its doors in 2014 (The Star, 2013b). Noteworthy is that established MNC subsidiaries have incorporated medical devices as well. Among these MNC subsidiaries are Agilent Technologies, Plexus, Knowles and Sanmina (InvestPenang, 2012). Thus although the industry appears to be quite small, more and more MNCs are getting involved in the medical equipment branch in Penang.

Figure 5.9: Lifespan of MNC subsidiaries in the Medical Equipment branch in the period 1994-2013.



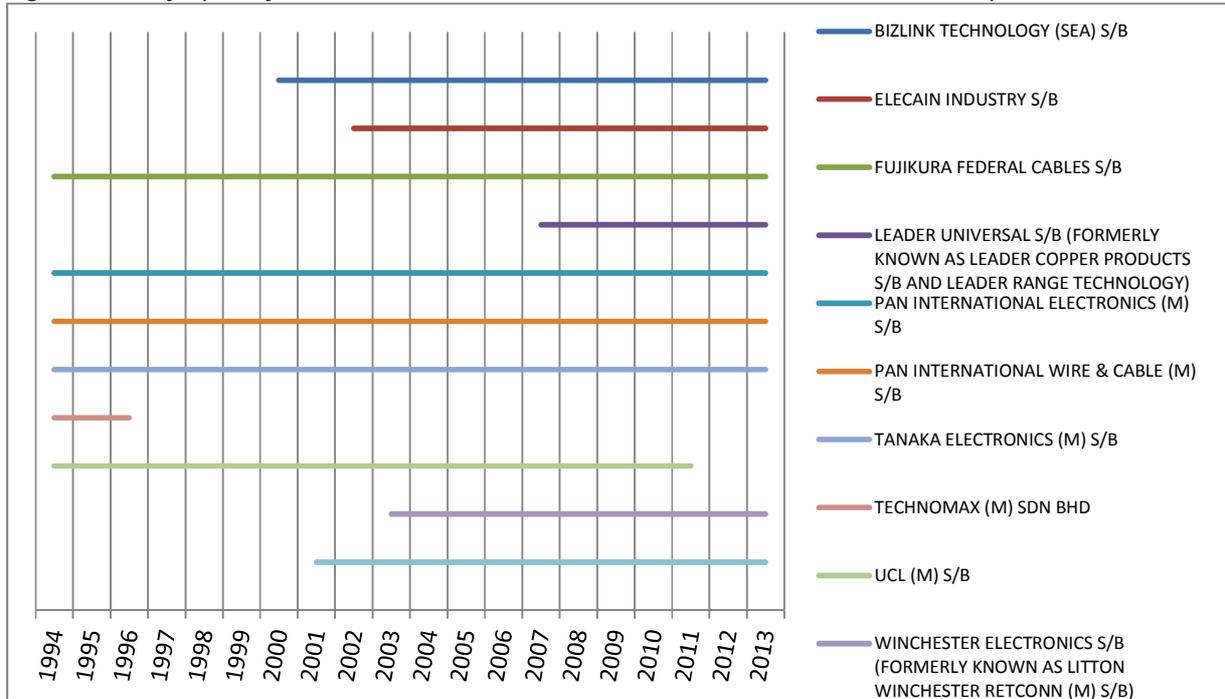
Source: Database 2013

5.3.8 Cables & Wire Harness

MNC subsidiaries within this branch are involved in the production of fiber optic, medical and hybrid cables and wire harnesses. As is illustrated in figure 5.10, between 1994 and 2013, MNC subsidiaries involved in the manufacture of cables & wire harness in Penang have increased with 50 percent, to a

total of 9 subsidiaries. During the same period only 2 subsidiaries, UCL in 2012 and Technomax in 1996, have exited the industry. The increase can amongst others be explained by a growing demand for high speed internet access. Worldwide cable providing MNCs have expanded their plants and upgraded their networks (Cable Spotlight, 2013).

Figure 5.10: Lifespan of MNC subsidiaries in the Cables & Wire harness branch in the period 1994-2013.

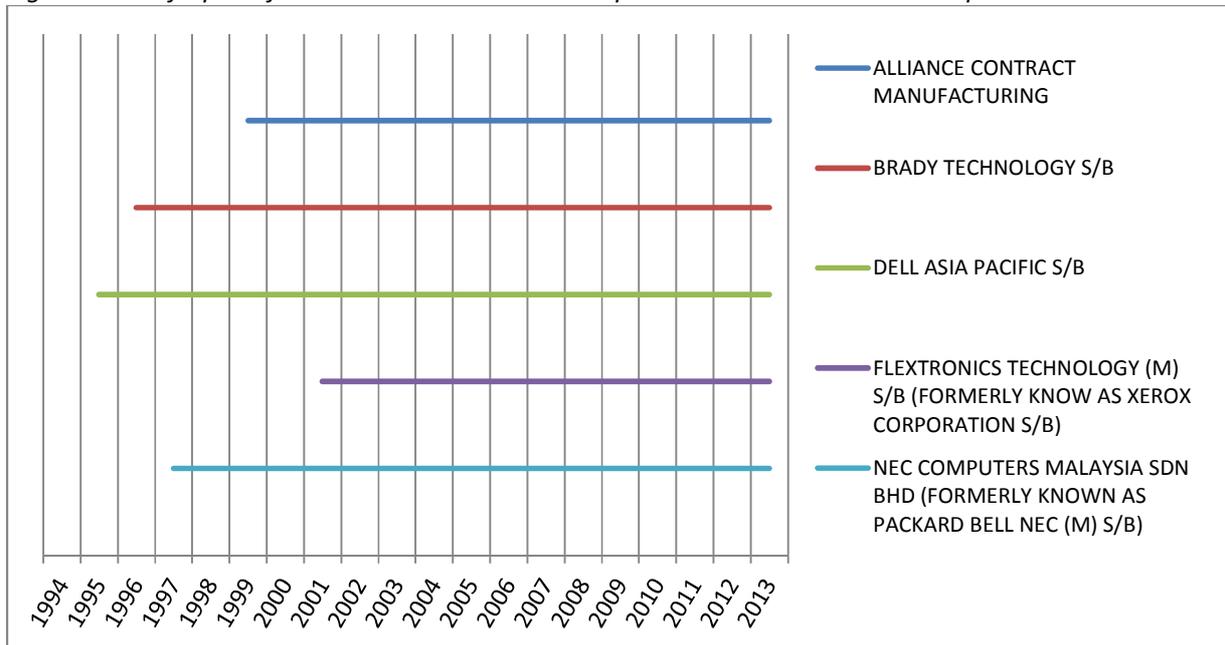


Source: Database 2013

5.3.9 Computer Hardware

The computer hardware branch consists of MNC subsidiaries involved in the manufacture of PCs, laptops, printers and other office equipment. As in 1994 not a single subsidiary was involved in the manufacture of computer hardware, the first entrant in this branch was Dell in 1995, followed by Brady in 1996 and Packard Bell (currently known as NEC) in 1997 (see figure 5.11). After the entries of Alliance in 1999 and Xerox (currently known as Flextronics) in 2001, the branch remained stable. Noteworthy is that the local Dell operations in Penang produce(d) the largest volume of laptops in Asia (Business Wise Consulting et al, 2007). However, according to Athukorala (2011), Dell and NEC have scaled down their operations in Penang due to competition from China for final assembly.

Figure 5.11: Lifespan of MNC subsidiaries in the Computer Hardware branch in the period 1994-2013.

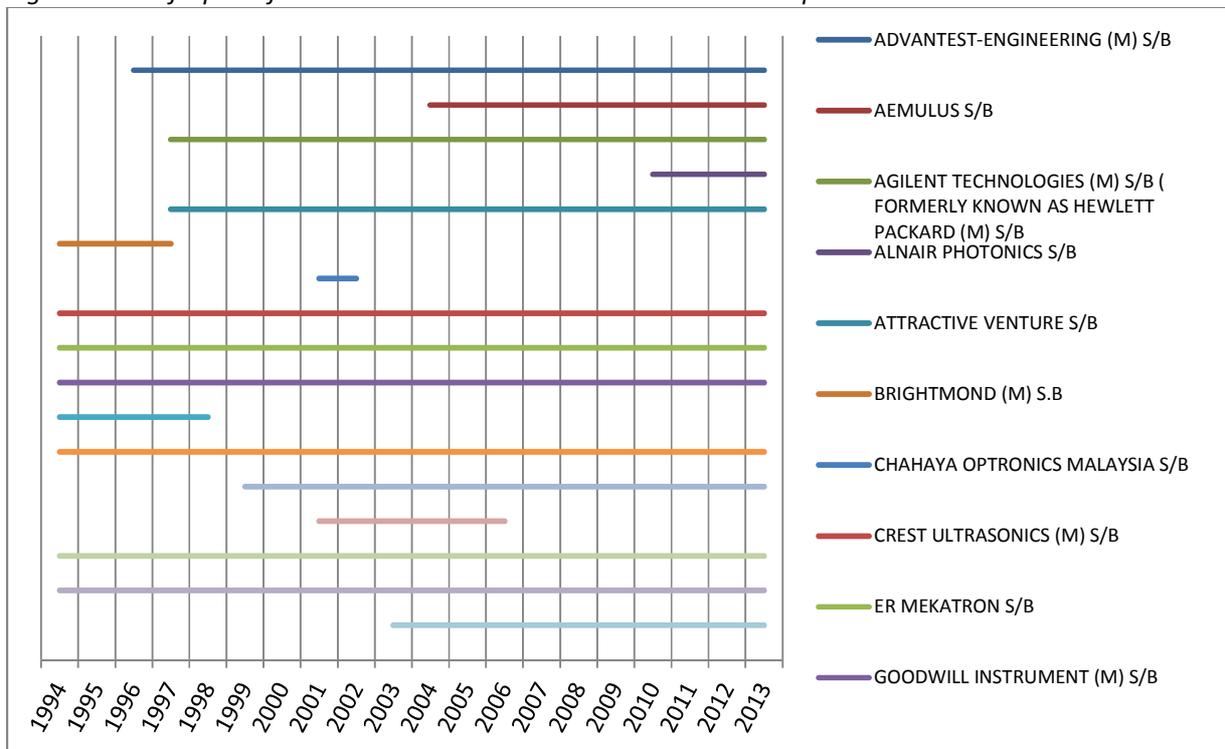


Source: Database 2013

5.3.10 Electronic Instruments & Measurement Equipment (EI&ME)

Compared to the earlier described branches, the EI&ME branch is considerably larger, which is illustrated in figure 5.12. This branch consists of MNC subsidiaries that are involved in the production of analytical, electronic test and measurement instruments, scanner/bar-code products, lasers, display screens, point-of-sales machines, and security system equipment. In 1994 the branch consisted of 8 MNC subsidiaries, while in 2013 this amount has increased to 13. During this period 9 MNCs have established a subsidiary, while 3 have exited the branch. Another important aspect of the EI&ME branch in Penang is the presence of Agilent (the separated technology division of Hewlett Packard) since 1997. The Penang operations of Agilent are the largest of the company worldwide outside the US (Business Wise Consulting et al, 2007).

Figure 5.12: Lifespan of MNC subsidiaries in the EI&MI branch in the period 1994-2013.

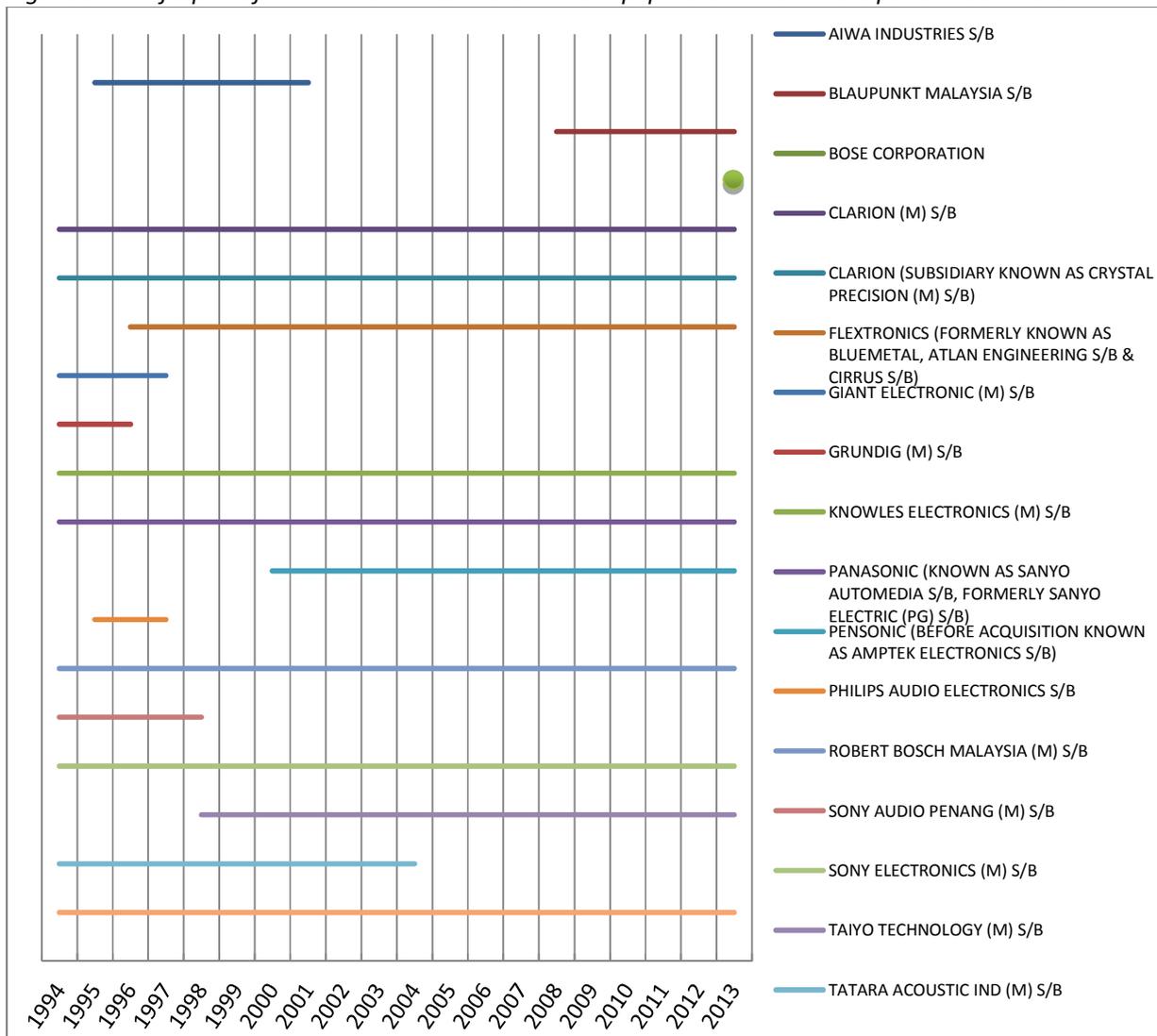


Source: Database 2013

5.3.11 Audio Equipment

The audio equipment branch is represented by MNC subsidiaries that produce audio equipment devices, which in Penang is mainly focused on (car) audio products. In 1994 the audio equipment branch in Penang encompassed some global audio giants such as Clarion, Grundig, Panasonic, Robert Bosch and Sony as is shown in figure 5.13. The branch reached its peak of 14 MNC subsidiaries in 1996, after which the branch slowly declined to a low of 10 subsidiaries between 2005 and 2007. By then Aiwa and Philips had entered and already left Penang as had Grundig and one of Sony's 2 subsidiaries.

Figure 5.13: Lifespan of MNC subsidiaries in the Audio Equipment branch in the period 1994-2013.



Source: Database 2013

In figure 5.13, especially the entries of major MNC subsidiaries Blaupunkt and Bose in 2008 and 2013 are remarkable. As audio equipment assembly is somewhat associated with (low-skilled) labor-intensive assembly, it is surprising that these MNCs did not allocate their facilities in low-cost countries such as China and Vietnam (Rasiah, 2010). However, the nature of activities in the newly established Penang subsidiaries seems to be different from plain assembly of audio equipment. As Blaupunkt already deploys some R&D activities in Penang, it announced to gradually transfer the design work from Germany to Penang (The Star, 2012c). Although Bose did not make a public statement on the functions of its Penang subsidiary, it is the firm's first subsidiary in Asia, which is said to be the key subsidiary in the corporate strategy to increasingly serve a booming Asian market (The Star, 2012d). The products of both Blaupunkt and Bose are focused on wireless and mobile media and entertainment systems, rather than traditional audio equipment. With these upgraded products, the audio equipment branch seems to have become more sophisticated internally. After the entries of Blaupunkt and Bose, the audio equipment

branch in Penang remained at 12 MNCs subsidiaries in 2013.

Finally, the branches containing manufacturers of capacitors, connectors and power management equipment have remained quite stable over time as in each of these branches just one MNC subsidiary left between 1994 and 2013. In this period, the telephone & facsimile machine branch even remained equal at a total of 5 MNC subsidiaries. The amount of MNC subsidiaries producing coils on the other hand, did increase from 5 in 1994 to 7 in 2013. The domestic appliances and the video equipment branch both experienced a similar increase from 4 to 6 subsidiaries. The amount of MNC subsidiaries manufacturing computer peripherals has increased slightly more significantly, from 5 in 1994 to 8 in 2013.

5.4 Conclusion

After the early years of exogenous implantation in the 1970s and 1980s, the E&E industry in Penang seemed to have reached its peak in the first half of the 1990s. To identify what has happened in the industry after this period, this chapter has provided insights into the evolution of the E&E industry between 1994 and 2013.

In the period 1994-1998 the industry still experienced a rapid growth mainly due to entries within the semiconductor and audio equipment branches. Besides this growth, the period can be characterized by the emergence of 2 new branches, the SSD and Computer Hardware branch. In the following period between 1999 and 2003 the growth of the industry had declined compared with the previous period, which might have been an aftereffect of the Asian Crisis in the late 90s. In this period, especially the HDD branch was severely affected. Although still growing, the E&E industry experienced a further decline of growth in the third period, between 2004 and 2008. Nonetheless remarkable, is the sustaining growth of the SSD branch in this period. The final period, between 2009 and 2013, is the least turbulent period in which the growth of the E&E industry almost seems to stagnate. This might be due to the global financial crisis negatively affecting global trade in manufacturing. In light of the above, it is surprising how the findings in this chapter differ from the first hypothesis formulated in chapter 3:

Between 1994 and 2013, only MNC subsidiaries from established branches have entered the E&E industry in Penang.

The hypothesis was based on the assumption that other regions in Southeast Asia had a competitive edge over Penang, especially due to a lack of skilled labor as indicated by the World Bank (2013) and Kharas et al. (2010). Therefore, there would be no reason to assume that Penang would be attractive for MNCs in more sophisticated branches. At the same time, countries such as China and Vietnam have emerged. Labor costs in these countries are considerably lower than in Penang and therefore these regions are more competitive for less sophisticated branches. In both cases, Penang would not be attractive for investments of MNCs in new branches.

However, the overall developments in Penang in the past 2 decades reveal a more versatile picture. The HDD has declined most significantly in total amount of subsidiaries. The emergence of the computer hardware branch in the 90s first seemed promising for Penang, but after 2001 the growth stagnated, possibly due to declining margins and later as a result of increasing competition of mobile devices such as smart-phones and tablets. With respect to related variety discussed in the theoretical framework, the strong base of semiconductor firms in Penang seems to have been important the composition of the industry throughout the years. While the semiconductor branch itself expanded, two technologically related branches, the SSD and LED, have entered the region and subsequently increased in amount of subsidiaries. The decline of the HDD branch and the emergence/expansion of the SSD and LED branches, also provide insights in the second and third hypothesis:

Between 1994 and 2013, MNC subsidiaries from sophisticated branches have left the E&E industry in Penang.

Between 1994 and 2013, the evolution of industry branches has revealed downgrading of the E&E industry in Penang.

Just like the first hypothesis, the second and third hypothesis can be rejected. Compared to the SSD branch, the HDD branch is less sophisticated. Although the technology for HDDs is more mature, SSDs have benefits in terms of speed and reliability. The only disadvantage of SSDs over HDDs are the production costs, but these are expected to decline in line with technological progress. Additionally, LEDs increasingly replace traditional light-bulbs. Throughout the years, LEDs have become more sophisticated. Light output and efficiency have increased considerably while production costs declined. Therefore LEDs are currently applied in a wide variety of products.

In light of the expansion of two sophisticated branches, the evolution of the audio equipment branch in Penang is quite remarkable. In his work, Rasiah (2010) associated audio equipment in Malaysia with rather low-skilled activities. The decline of the audio equipment branch in Penang after the peak in 1996 would be in line with the decline of less sophisticated branches, as represented by the HDD branch. However, after the gradual decline since 1996, 2 leading MNCs in the audio equipment branch, Blaupunkt and Bose, entered Penang in 2008 and 2013. The products of both Blaupunkt and Bose are focused on mobile media than the assembly of low-end traditional audio equipment. Also through internal product upgrading, the audio equipment branch in Penang has become more sophisticated.

Chapter 6: In situ upgrading in Penang

6.1 Introduction

When MNCs moved their production to Penang in the 1970s and 1980s, other functions such as sales, management and R&D remained in their home country. With respect to production, MNCs initially focused mainly on manual labor, which back then was affordable in Penang because of the low wages. Throughout the years however, as overall welfare of Penang increased, wages increased accordingly. Therefore, when China opened its doors to foreign countries from the 1990s onwards, MNCs started to move labor-intensive activities in their value chain away from Penang, since real cheap labor became available in regions in other countries. As trends show that MNCs relocated their labor-intensive activities to countries such as China, Cambodia and Vietnam and the previous chapter has shown that in the past 2 decades quite some MNCs have remained in (or even relocated to) Penang the question arises what has happened to the activities within the Penang subsidiaries of these MNCs.

While the previous chapter looked at evolution as a result of entries and exits at the industry level, this chapter will take a closer look at what has happened at the subsidiary level. To identify changes at the subsidiary level, a series of interviews, lasting from 50 to 120 minutes, were conducted with managers, directors or executives of 31 MNC subsidiaries in Penang with knowledge of past developments within their subsidiary. These interviews are an attempt to determine whether or not these subsidiaries have upgraded their activities by examining their functions, products and production processes. In close relation to these activities, it is important to identify by which underlying mechanisms the changes in these activities are determined.

To find out more about the developments on the subsidiary level the respondents were asked questions about the position of the subsidiary within the MNC, how this position was influenced by the firm's RPN and how this position has changed over time. Furthermore, the respondents were asked about internal matters of the subsidiary, such as its functions, products and production processes, the skill levels of its employees and learning processes. Finally, to put this into a broader perspective, the interviewees were asked about their subsidiaries' relationships with other actors in Penang such as the government, local suppliers and other firms and the influence of the regional characteristics on the performance of the subsidiaries. Additionally, they were asked about their perception of the Penang region and the increasing competition from China, Cambodia and Vietnam.

All subsidiaries in the sample have operations in 2 or more countries. However, the MNC subsidiaries in the sample vary in size and country of origin. The largest subsidiary employs 9.000 workers, while the smallest has a workforce of 4. Most subsidiaries are US-based, but other countries of origin are Germany, Ireland, Japan, Sweden and Taiwan. About 23 percent of the subsidiaries is Malaysian. Most of these firms are spin-offs or former suppliers of MNCs, that have grown out to become MNCs themselves. Particularly the development of these subsidiaries from "spoke" to "hub" in the region is of interest for this research.

As described in the methodology, the subsidiaries have been selected in such a way that the sample gives a suitable representation of the E&E industry in Penang. As a result, the 31 subsidiaries interviewed account for 13 different branches. However, this selection implies some restrictions on the analysis. While the EI&ME, Cables & Wires harness, semiconductors and computer peripherals branches are most well-represented, the other 9 branches are represented by just one or 2 subsidiaries. Unfortunately, this broad selection of subsidiaries has made it difficult to generalize findings for specific branches.

The remainder of this chapter will start with an analysis of the development of the past 10 years at the subsidiary level. First, functional, product and process upgrading (or the lack of it) within the subsidiaries will be reviewed. As the charter of a subsidiary is related to the change in functions,

products and processes the following sub paragraph is centered on this subject. In chapter three the evolution will be explained on the basis of regional characteristics. Then, in the fourth section, the MNCs' commitment to the Penang region will be discussed, based on the perception of the interviewees of its regional characteristics. The fifth part gives an impression of the MNCs' position within the RPN of the MNC, how this has changed over time and how it has influenced their charter and capabilities. The sixth section shows the vision of the respondents about the future prospects for their subsidiary. Finally, the last part presents final remarks about the evolution at the subsidiary level, by taking all the developments and their underlying mechanisms into account.

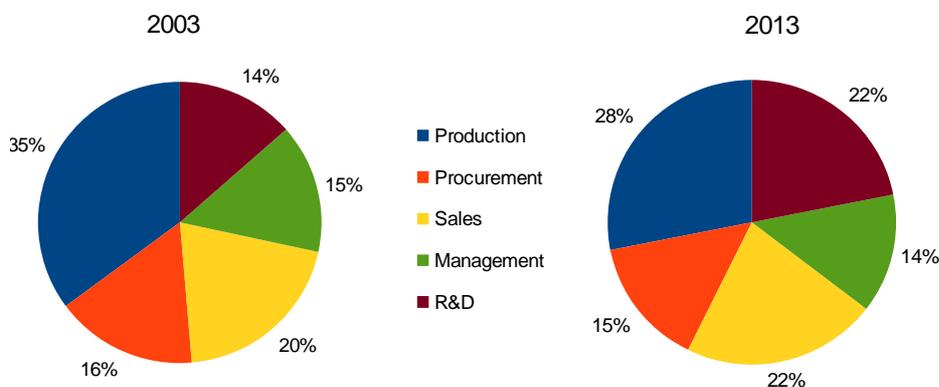
6.2 In-situ evolution

6.2.1 Functions

The main functions of MNC subsidiaries in the E&E industry in Penang are, in increasing order of value-added: production, procurement of materials, sales/marketing, management and R&D. A subsidiary often deploys more than just one function. Furthermore, the functions of a subsidiary are not static, but may change over time. Therefore, it is important to identify both the current functions, as well as the functions at a previous moment in time - in case of this research ten years ago.

Following the history of the early establishment of production facilities by MNCs in Penang, production would be expected to be the major function among the MNC subsidiaries. Figure 6.1 below confirms that production indeed was the most dominant function in 2004 among the MNC subsidiaries interviewed. Although production has become relatively less important in 2013, production remains the major function. Except for R&D, the other functions show just some slight mutations in which they balance each other out. Among the subsidiaries interviewed the amount of subsidiaries with an R&D functions has strongly increased.

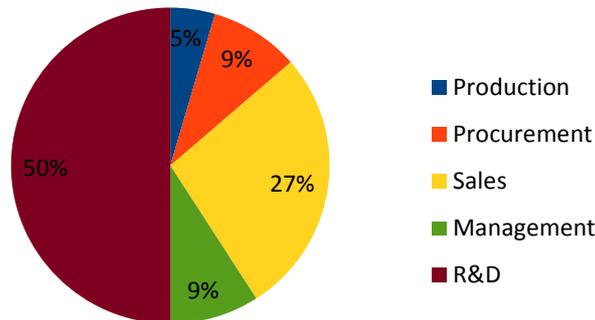
Figure 6.1: the share of each function within the sample in 2004 and 2013.



Source: All interviews conducted; see references

With respect to figure 6.1, it must be noted that the overall amount of functions has increased between 2004 and 2013. In 2004 all subsidiaries together deployed 75 functions, which in 2013 had increased to 97 with 22 new functions. On average, in 2004 a subsidiary deployed 2.4 functions, while 10 years later a subsidiary deployed 3.1 functions. To see where this difference comes from and which functions have increased in particular, figure 6.2 below shows the share of each function among the 22 new functions.

Figure 6.2: The change in functions of MNC subsidiaries in Penang between 2004 and 2013.



Source: All interviews conducted, *see references*

Figure 6.2 helps to get insight in the dynamics of the change in functions. It stands out that production is the least frequently added function, but as indicated previously the majority of all subsidiaries already deployed a production function. More interestingly, from the 22 functions added, sales and R&D accounted for 77 percent of the change. R&D in particular accounted for 50 percent of the change between 2004 and 2013.

Overall functional evolution: upgrading or downgrading?

Compared to 2004, the amount of subsidiaries deploying R&D activities has more than doubled in 2013. Furthermore, there have been slight changes within the functions procurement of materials, sales and management. To get a clear view of the extent to which the developments between 2004 and 2013 have led to functional upgrading, a functional sophistication index is constructed as explained in Chapter 4. For this index each function has been assigned a unique value in accordance with its level of value-added. Finally, all values are summed up and subtracted by the total amount of functions, resulting in the functional sophistication index. The outcome of this index is a number between 1 and 5, which should be interpreted as a grade which represents the level of functional sophistication in a region. The function of the index is represented in the formula below:

$$\text{Functional sophistication index} = \frac{\sum(X_i * V_i)}{\sum(X_i)}$$

X = subsidiary deploying function i

V = the assigned value of function i

This index can be compiled for both 2004 and 2013. For 2004, the functional sophistication index was 2.6, while in 2013 this was 2.9. In 10 years, the average functional sophistication of the MNC subsidiaries in the sample has upgraded with 11 percent. To give a clear interpretation of what these numbers say about functional upgrading in Penang, it would be helpful to compare the results to other regions or the country average. Unfortunately, as these figures are unavailable, the index should be interpreted as an indication that functions in Penang have upgraded. To what extent the functions have been upgraded, will be explained in further detail below.

Upgrading towards R&D

Out of the 21 subsidiaries with an R&D function in 2013, 11 of them have at least 10 percent of their workforce assigned to R&D activities. Some of these MNC subsidiaries even have a major part of their

workforce committed to R&D, such as the US-based Altera, Agilent, Intel and sTec (which is incorporated in the HGST division of Western Digital) and Germany-based Kontron.

Although Agilent is also involved in production and sales, 25 percent of its 4.000 employee workforce is involved in R&D. Even compared to Agilent, Intel's Penang workforce of 9.000 employees is quite impressive. Intel is besides in R&D, involved in all other functions. In the interview, the respondent from Intel indicated that its workforce committed to R&D activities has increased 10 times in the past 10 years. Currently 40 percent of Intel's total workforce is dedicated to R&D activities, which are about 3.600 employees.

The history of sTec is rather different compared to market leaders such as Agilent and Intel. Since its establishment, sTec has rapidly grown out to become a technology leader within the segment of enterprise SSDs. The firms' patents and expertise has attracted attention of HDD giant Western Digital. As sTec is recently incorporated in HGST (a fully owned Western Digital subsidiary), it is now the cornerstone of HGST's division of enterprise SSDs. Since its establishment in 2006, the Penang subsidiary of sTec was initially responsible for production. In 5 years the Penang subsidiary has been expanded with an R&D facility in which currently 20 percent of the 500 employees workforce is active.

Subsidiaries without production

Where production formed the basis of the technological development of Penang, 4 MNC subsidiaries have decided to discard their production function. Kontron and Altera for instance are currently strictly involved in R&D, although their Penang subsidiary used to deploy production activities in the past. Altera outsources all its manufacturing activities locally, so their Penang subsidiary, and the majority of its 1.200 workers, is fully focused on R&D. This coincides with the global strategy of Altera, in which they focus on in-house development of new technologies for semiconductor devices. For the actual production stage of their products, they work together with other companies to do the manufacturing. Therefore, all Altera's subsidiaries consist of sales offices and R&D facilities, such as the subsidiary in Penang.

Cisco runs a similar business model, based on outsourcing. At the Penang subsidiary of Cisco, all production of their IT equipment is based on outsourcing to their contract manufacturers. In the case of Cisco however, outsourcing means more than just the redistribution of the subsidiary's production to other firms. Besides production they also outsource the procurement of materials and their R&D activities. Additionally, they make investments in the contract manufacturing firms in terms of materials, machinery and the provision of professional R&D workers. The full-time job of the 85 managers employed in the Penang office is aligning and controlling these functions.

6.2.2 Products

As described in the previous section, quite a few MNC subsidiaries in the Penang E&E industry have upgraded their functions. In several cases this has resulted in a shift towards R&D. The result of functional upgrading may also result in a change of products. Products become more sophisticated in order to meet market demand. Besides a change in their existing products, subsidiaries expand their product portfolio with new and/or different product lines. Subsidiaries change or expand their product portfolio in order to be more competitive, interact with changes in demand and target new markets.

Towards more value-added products

The vast majority of the subsidiaries in Penang is involved in production operations and more than half of these subsidiaries have changed their product portfolio over time. Either they have diversified by expanding their product portfolio, or they have completely changed their product line. Overall, the subsidiaries made this change to add more value to their products. The majority of the MNC subsidiaries is still producing the same product as before, but expanded their product portfolio with different products. In 1994 for instance, AMD was producing mainly central processing units (CPUs) after which it

expanded its product folio with accelerated processing units (APUs) in order to add more value to its products. A similar example is Brady Technology, which started with the production of labelers and have expanded with the production of and dye cut parts and printers capable of printing holograms.

Next to an expansion of products sometimes a complete shift in focus of products occurs. Until 1997, Hewlett Packard (currently known as Agilent) had its main focus on producing semiconductors, but in 1997 they shifted towards measurement equipment. This became their main focus from 1999 onwards, when Hewlett Packard separated its technology division which continued as Agilent. Another example of a changing focus of products is Globetronics. The firm started as a supplier for MNCs in Penang producing low-end burn-in devices, but along the way they started to develop their own products with a focus on more sophisticated semiconductor and LED products.

Global technological progress

Subsidiaries change their product portfolio to become or remain competitive and to meet market demand. More than half of the subsidiaries interviewed made changes in their product portfolio over the past ten years, usually to add more value to their product portfolio. Besides diversification of products, changes also occur within the same product line. For instance, 10 years ago memory sticks were larger and had less storage capacity compared with current memory sticks. The product has remained similar, but the product has become more advanced. This change in the same product line can be explained by an ongoing technological change due to an ongoing demand for more advanced products. In order to be competitive, MNC subsidiaries have to keep up with global trends. All subsidiaries have adopted product changes whereby the product has become more sophisticated and complex.

In part, product upgrading can be seen as an ongoing evolutionary process related to market demands and global trends. However, some MNC subsidiaries are capable of more than just keeping up with technological developments. To find out whether subsidiaries have been involved in technology-enhancing activities themselves, the respondents were asked whether the products produced by their subsidiaries were new for the market. As 11 MNC subsidiaries indicated to have been involved in producing new products for the market, among them were all the 4 MNC subsidiaries with more than 1.000 employees: Agilent, Altera, AMD and Intel.

6.2.3 Processes

Changes in functions and products are accompanied by changes in processes. For sophisticated functions like R&D or in order to produce more sophisticated products, more complex processes are required. For production, this change demands higher-skilled labor and sophisticated machinery. At the same time subsidiaries are shifting towards more value-added functions, whereby machinery is less required compared to higher skilled labor. Although many subsidiaries have upgraded their functions, nearly every subsidiary in Penang is still involved in the manufacturing of products and therefore the production process at most subsidiaries is largely automated.

Automation or labor-intensive processes?

At large manufacturing sites such as the subsidiaries of Agilent, AMD, Intel and sTec the level of automation is very high and labor is strictly used to manage the production process. In addition to the highly automated production process, the level of the sophistication of the machinery they use for their production is also high. The production process is monitored by personnel that does not necessarily needs to be highly trained. However, as besides production Agilent, Intel and sTec are involved in R&D, this function does require high-skilled personnel. This is reflected in the subsidiaries' share of high-skilled personnel. While AMD has a low share of high-skilled personnel, Agilent, Intel and sTec all have a highly skilled workforce.

There are also several subsidiaries with a rather low level of automation. Altera for example established an R&D center in Penang in 1998 and, as mentioned earlier, is mainly involved in activities that are related to R&D of products instead of production activities. In this case, the level of automation depends not as much on the sophistication of the production process, as it depends on the function deployed by the subsidiary. Although scarcely automated the level of the sophistication of the machinery is very high at Altera. This depends rather on the product, as the complexity of R&D activities with respect to semiconductors is very high. Despite the expensive machinery for R&D, compared to the high investment in labor the investment in machinery at this subsidiaries is low.

Approximately a third of the interviewed subsidiaries have a large share (50 percent or more) of high skilled employees of their total employment. As previously described, among these are subsidiaries of global leading firms such as Agilent, Altera, Cisco and Intel. At the same time there is still a large amount of subsidiaries where only a small share of the total employment is high skilled. These are in general subsidiaries that are involved in the manufacturing of less sophisticated products such as Eng Teknologi, Escatec and Precico. Eng Teknologi is the only subsidiary engaged in R&D, but only with 2 percent of its workforce. Escatec and Precico are not involved in R&D, which is reflected in a large share of low-skilled workforce. Nonetheless it is surprising that these 3 subsidiaries still have a rather large workforce (between 280 and 850 employees), while the respondents indicated that the production process in their subsidiaries is highly automated.

Process control

For productive or R&D activities, most MNC subsidiaries in Penang have acquired quality control certificates (QCCs). For the E&E industry, the most important certificates are ISO9000 and ISO14000. The majority has at least ISO9000 capabilities, but ISO14000 is also common. Additionally, quite a few subsidiaries are TS16949 certified, which is important for clients in the automation industry. Overall, the certificates imply a certain quality of the production process and the products produced towards their customers. However, some respondents consider the QCCs to be more a prerequisite than an indication of the sophistication of their processes. For most subsidiaries it is a minimum requirement in order to attract clients.

Technology acquisition

Although the majority of the MNC subsidiaries currently has R&D activities in Penang, the way subsidiaries acquire new technologies for their products and processes differs. Most subsidiaries acquire new technologies through own R&D. In some cases technologies are also transferred from the HQ. For subsidiaries that are not involved in R&D activities this is a way to nevertheless acquire new technologies. Furthermore only a few subsidiaries collaborate with other firms to acquire new technologies. In even more exceptional cases knowledge is acquired through the acquisition of another firm. This can be illustrated by the recent acquisition of sTec by Western Digital in 2013.

The subsidiaries involved in R&D activities all focus on the development of new products and processes. Just some of them are also engaged in the adaption of products and processes. Although patents are important for protecting certain technologies only few subsidiaries are involved in filing them. Exceptions are Altera and sTec, for which patents are very important. Altera has even set patent targets for every year.

6.2.4 Charter development

Related to the change in functions, products and processes described above is the development of a subsidiary's charter. The responsibilities of a subsidiary can vary among different domains. These domains include decisions about the allocation of product lines, the product portfolio, process changes,

functions, procurement of materials and operational matters. In the interviews, as perceived by the respondents, the majority indicated that their subsidiary has full responsibilities on most domains.

It must be noted however, that in Penang quite some of the MNC subsidiaries in the sample have an HQ-function: 6 subsidiaries are an RHQ (usually for the ASEAN or APAC-region) and 8 subsidiaries are an HQ. The responsibilities with regard to decision-making are in line with what would be expected: these subsidiaries have almost full autonomy on all domains in their own subsidiary and also make decisions about other subsidiaries. Nonetheless, the subsidiaries that do not deploy an HQ-function, also make decisions autonomously.

Except for Escatec, the subsidiaries with an HQ-function are all originally from Penang. These subsidiaries include Eng Teknologi and Globetronics, 2 firms that started as local suppliers for MNCs such as Seagate, Western Digital and Intel, but have grown out to become MNCs themselves. The Intel subsidiary in Penang has an RHQ function for the APAC-region, as well as Agilent, Altera and Cisco. Throughout the years these subsidiaries have become an important pillar in Asia with respect to the global strategy of their MNCs.

6.3 Interpreting evolution/regional characteristics

6.3.1 Employment

As mentioned in the introduction of this chapter, MNCs seem to be moving labor-intensive functions to other countries, since labor costs in Penang are no longer competitive for these activities. As the E&E industry is highly knowledge-intensive, a prerequisite for MNCs in Penang willing to upgrade is the availability of workers that are capable of conducting knowledge-intensive activities. From the viewpoint of MNCs seeking upgrading, it is important that the labor market in a region serves them in: (1) the availability of labor, (2) at competitive costs, (3) with sufficient skills and knowledge. In addition, (4) the presence of training institutions contributes to the skill level of the labor force.

From the interviews, almost all of the respondents consider both the availability and the costs of labor to be important to very important for upgrading in Penang. Looking at their evaluation of the availability of labor on the other hand, shows that MNC subsidiaries are just marginally more positive than neutral about the current situation in Penang. For these respondents the costs of labor in Penang are even slightly worse than neutral.

Looking at the skills, there is even more consensus among the subsidiaries as all – except one respondent – MNC subsidiaries view skills to be important to very important for upgrading in Penang. With respect to training institutions there is less agreement, but still most respondents see them as important. Following the publications of the World Bank (2013) and the Penang Institute (2013a) in the chapter about regional characteristics, labor skills and training institutions are expected to be weak in Penang. Surprisingly, skills and labor training institutions are both evaluated as better than average.

When asked about the indicators that have played a major role in the past (lack of) upgrading of the subsidiary, the majority of the respondents referred to labor indicators. According to the respondents, the most important asset of Penang are the availability and the low costs of high-skilled labor (usually relative to the home country of the MNC subsidiary). This was not just the case for subsidiaries of large MNCs involved in R&D such as Agilent, Altera, Intel and sTec, but also acknowledged by subsidiaries of smaller firms. Especially Aemulus and BH Electronics referred to the importance of skills in Penang for past and future upgrading.

6.3.2 Technology base

While the presence of firms in related branches can lead to the diffusion of knowledge, the technology base of a region can be conducive to upgrading of the subsidiaries involved. Besides firms, the technology base consists of organizations such as research- and educational institutes as they contribute

to the development of new technologies. Additionally, government technology programs can also help improve the technology base of a region.

From the overall technology base in Penang, the MNC subsidiaries perceived educational institutions as the most important. Towards the importance of other firms, research institutions and government technology programs the respondents were more reserved as they considered them to be just a slightly important contribution for upgrading of their subsidiaries.

As the interviewees were moderate about the importance of the technology base, it is remarkable that they were quite negative in their evaluation. From the indicators, Penang only scored slightly better than neutral when they were asked about the presence of other firms, while the respondents were neutral about educational institutions. From the respondents over 60 percent judged the research institutions and government technology programs in Penang as bad or very bad. The negative reactions did not just come from small and medium-sized MNCs such as Bizlink, Eng Teknologi, and G-Shank, but also from AMD, Brady Technology and Intel. During the interviews, the respondents added that besides the low quality of the research institutes available, real initiatives from the government to improve the technology base are lacking in Penang.

The lack and low quality of proper research institutes might be problematic for future development of the skills of the labor force. Although in-house training and on-the-job experience are valuable, these types of training are predominantly relevant for manufacturing purposes and not so much for improving research or design capabilities. Most subsidiaries have indicated that their employees are involved in PSDC (or similar) training programs, but they consider the PSDC (and institutes such as Dreamcatcher and Talentcorp) more to be an educational institute. They educate college graduates and teach them the knowledge and skills they require for their future jobs, but they do not initiate research projects to improve future knowledge. Since not all MNC subsidiaries will be capable of making large investments in research, this is a gap the government could anticipate in.

Clearly, the educational institutes also require more attention. The E&E industry requires a well-trained and skilled workforce. Despite the 22 public and 31 private institutions of higher learning, the respondents do not consider these institutions to be sufficient. Following the interviews, except for the presence of firms with high technological expertise, the technology base in Penang overall would benefit from improvements.

6.3.3 Infrastructure & connectivity

Because most MNCs in Penang are export-oriented, the infrastructure needs to match their requirements. The infrastructure can be distinguished in physical infrastructure (such as the road network) and digital infrastructure. Since firms need to be able to move products from A to B in a reasonable amount of time, connectivity is strongly related to the physical infrastructure although for connectivity not just the road network is of importance, but also Penang's seaport and international airport. The scale levels of connectivity can vary from local, to national or even international. As international trade increases, connectivity at all scale levels becomes more and more important. Digital infrastructure in terms of internet connectivity is also becoming increasingly important. Digital infrastructure does not just refer to the presence of internet connections, but also to stability, speed and latency.

Following the interviews, all respondents perceived the physical infrastructure as important for their subsidiary. The digital infrastructure is even considered to be slightly more important. Regional, national and international connectivity are all viewed as important for the subsidiary. Interestingly, regional and international connectivity were judged as (slightly) more important than national connectivity. This might reveal the international focus of the subsidiaries interviewed and their linkages with their local suppliers.

The respondents evaluated Penang's connectivity as good. They were most satisfied about Penang's international connectivity, but they were also positive about its regional and national level connectivity. Regarding the physical infrastructure the interviewees were moderately positive, though on average they felt as if there is still room for improvement. They even felt stronger about the need for improvements when they were asked about the digital infrastructure. Although it is regarded to be the most important infrastructure, the digital infrastructure in Penang is not yet satisfactory.

Especially the respondents of Agilent and Altera were reserved about the initial quality of enterprise internet connections in Penang. Because of their dependency on internet connectivity and the high standards these firms manage, they require more from the infrastructure than standard connectivity and stability. Therefore they have made large investments on their own by constructing a complete digital infrastructure for their Penang subsidiaries.

6.3.4 Embeddedness

Since production is still the most dominant function among the MNC subsidiaries in Penang, the supply base in the region is highly relevant. During the interviews, the majority of the respondents confirmed that both the quality and the diversity of the supply base contribute to the performance of their subsidiaries and is therefore key to upgrading. As products become more complex and sophisticated, so does the complexity and sophistication of the parts and components that are used in them. MNCs require a quality of components that matches the quality they aim for in the final product. Especially MNCs that heavily rely on components from other firms require a strong and solid supply base. Both the quality and the diversity of the goods supplied contribute to the overall appreciation of the supply base.

When evaluating the supply base of Penang, the respondents judged it better than mediocre, but saw room for progress. Although both the quality and diversity would benefit from improvement, particularly the diversity of the Penang supply base could do better. Especially when comparing Penang to other locations in which their MNC operates, such as the US, Japan and Taiwan, respondents perceived the diversity of the supply base in Penang was lagging behind. This lagging behind may be inherent to the low level of entrepreneurship in the region.

When evaluating the supply base of Penang, the respondents judged it overall better than mediocre, but they saw room for improvements. Particularly the diversity of Penang is not as good as it could be. Especially when comparing Penang to other locations in which their MNC operates, such as the US, Japan and Taiwan, the respondents indicated that the diversity of the supply base in Penang was lagging behind. This lagging behind may be inherent to the low level of entrepreneurship in the region, as referred to by Henderson & Phillips (2007).

Looking at the embeddedness of MNC subsidiaries in Penang from the perspective of the labor market, the interviewees were asked about the ratio of foreign versus local workers in their subsidiaries. Most respondents indicated that less than 25 percent of their workforce consisted of foreign workers. Bizlink, BH Electronics, Fujikura and Precico stood out, because the majority of their workforce did consist of foreign workers. Except for BH Electronics, these firms are all involved in low value-added activities. As for most MNC subsidiaries in Penang, the largest part of the workforce consists of local workers revealing a certain embeddedness in the local community, embeddedness seems less necessary for low-level activities.

Box 6.1: Overview of training and research institutions in Penang

PSDC – Penang Skills Development Center. Founded locally by semiconductor MNCs in cooperation with the state government of Penang.

CREST – Collaborative Research in Science, Engineering & Technology. Initiated by universities, the E&E industry, the government in Penang.

TalentCorp – Facilitate initiatives to increase the availability of skilled labor in Malaysia. Established by the federal government.

DreamCatcher – Local training center for the E&E industry. Privately founded in Penang.

Public-private partnerships

In addition to the supply base, public-private partnerships (PPPs) give an indication of the embeddedness of subsidiaries within their region. The PPP most commonly referred to among the respondents is the PSDC, in which almost all subsidiaries are involved. As the PSDC originally was co-founded by Intel and Hewlett-Packard (currently Agilent), obviously these subsidiaries are still well committed to the initiative. Other active MNCs with board members in the PSDC are Altera, AMD, Bosch and Eng Teknologi. Since 2012, Altera, Agilent, AMD and Intel are all also engaged in CREST. Furthermore, several respondents indicated to be involved in TalentCorp and DreamCatcher.

Besides its engagement in technology-enhancing and labor-training institutions such as PSDC, CREST, TalentCorp and DreamCatcher, AMD also mentioned to have plans to become directly involved in educational institutions in Penang, such as universities and business schools. The gap between the active knowledge of graduates and the practical skills they require for the jobs they seek, was identified by AMD as most problematic regarding Penang's workforce. Therefore they want to collaborate with universities, by giving input from the industry on which courses can be valuable and relevant for future careers. Agilent, Intel and sTec are already involved in similar collaborations.

In addition to the local supply base, the respondents were also asked about their most important clients. Although most subsidiaries are export-oriented – especially the subsidiaries of large US-based MNCs – for some subsidiaries their most important customers were local. Overall, the MNC subsidiaries seem reasonably well-embedded in Penang, although the quality and diversity of its supply base could improve compared to regions in Japan and Taiwan.

6.3.5 Government

As mentioned in Chapter 5, the government has played a key role in the history of industrial development in Penang. Throughout the years they attempted to attract foreign investments with policies and incentives, which has proven to be quite a success in the past. As the government policies are still focused on attracting MNCs, it is interesting to see how the subsidiaries value these policies. Besides policies and incentives, government efficiency, pro-activeness, political stability and interaction potential can be of importance for MNCs when they (have decided to) invest in Penang.

Malaysia is governed by the national party, which is appointed each 5 years by the people through elections. At the state level, people can also vote their representatives. Although most states are also governed by the national party, in some states the opposition rules, which since 2008 is also the case in Penang. Therefore, in the interview a distinction was made between state and federal government. The respondents however, painted the state and federal government with the same brush. Not that they saw the 2 governments as intertwined – definitely not since the opposition rules in the state of Penang – but rather in terms of authority. As perceived by the interviewees, the government at the state level was important, but they felt that real transformations could only be implemented by the federal government.

From the interviews it became clear that the importance of the state and federal government keep each other in balance most of the time. With respect to policies and incentives the interviewees made it clear that these were initiated at the federal level and the state government was not involved at this point. The respondents considered efficiency and interaction potential more important at the state level than at the federal level, while pro-activeness and stability were viewed as more important at the federal level. At both levels, stability and efficiency were perceived as most important, while interaction potential was regarded as mildly important.

As overall the government was seen as an important actor for their subsidiary, the respondents were least positive about the federal government. Although judged at most points from moderately to fairly good, the interviewees did not perceive the federal government as pro-active. At the state level, the respondents were more positive on all points, although the state government was never valued as good either. Furthermore it must be noted that at first, most interviewees were not too keen to talk about the government at all. Along the way they became less reluctant to answer, but it might still have affected the results.

6.3.6 Living environment

The living environment can have a positive impact on attracting MNCs, especially when, in turn, the MNCs seek to attract high skilled employees. In this case the living environment can contribute to upgrading of the subsidiary. For MNCs aiming at hiring lower skilled employees, the living environment is also important because future employees need affordable and reasonable housing. Additionally, a good health-care infrastructure can contribute to the wellness of the workers and low absenteeism is beneficial for a subsidiary's operations. Other factors contributing to a pleasant living environment are low pollution, crime and congestion, nice cultural amenities and affordable schools with decent education.

In the interviews, all factors influencing the living environment were considered almost equally important, although cultural amenities to a lesser extent. The evaluation of the living environment, showed more differentiated results. Health-care and cultural amenities in Penang were perceived as good. Especially with respect to health-care the respondents often referred to the increasing medical tourism, indicating that many people from neighboring countries come to Malaysia to seek medical attention. Most interviewees were also reasonably satisfied by the schooling in Penang, in particular by the low costs and wide availability. However some of them pointed out that they were highly critical about recent changes in national policy that replaced the main language taught in school from English to Malaysian.

As for pollution and crime, the respondents were mildly positive. They seemed to take a little pollution as given, since they lived on a densely inhabited island, although they did suggest that the environment could be improved. With respect to crime, several interviewees explicitly indicated that the past decade crime rates have risen sharply in Penang. This was also illustrated by a recent article in the Economist (2013). Overall, there haven't been many crimes reported regarding the MNCs in Penang as was confirmed by the interviewees.

During the interviews, the respondents were least positive about housing and congestion. As for housing, the respondents indicated that now Penang is getting very crowded it is increasingly hard to find a good place to live which is still affordable. Prices of real estate have risen disproportionately the past decade(s), especially on the island. Although Penang is getting denser, according to the interviewees the road network on the island is not prepared for more traffic. While there are already quite a few traffic jams, the amount of commuters between the Northern (residential area) and Southern (industrial area) part of the island still keeps increasing. The respondents were not optimistic about future developments regarding congestion problems.

6.4 Penang commitment

According to the theories described in Chapter 2, up- and downgrading processes within an MNC subsidiary can be explained by its embeddedness within the region and its position within the MNC. In turn, this embeddedness and its position are related to the commitment of the MNC to that region – in this case Penang. Why did MNCs choose to up- or downgrade their Penang subsidiaries? In the interviews with MNC subsidiaries, the respondents were asked about the commitment of their MNC to the Penang region. To place these perceptions in a longitudinal perspective, the respondents were also asked whether and how the regional characteristics of Penang have changed compared to 2003, hereby influencing the MNCs locational commitment. In addition, the respondents were asked whether or not their MNC had made investments in the past decade to expand its operations in Penang, because this is also an indication of commitment to a region in terms of capital invested. With regard to increasing competition of other Southeast Asian regions, finally the respondents were also asked about their opinion of Penang compared to alternative locations.

6.4.1 Changes in the Penang region

In light of the above perceptions of Penang, the respondents of the MNC subsidiaries were also asked about how the region has changed over the past 10 years. Although some of them were not too glorified about the current situation, overall the respondents perceived the Penang region as being improved. The respondents from Agilent, Kobay and sTec were most satisfied with the development of the region. The only negative reaction came from Altera, whose respondent perceived the current situation in Penang as worse compared to 10 years ago.

6.4.2 Expansions

In addition to the perceptions of the development of the region, an MNC can show commitment by expanding its established subsidiary. During the interviews, most respondents indicated that their subsidiaries have expanded either on the same or on a new location and in some cases both. Especially Agilent, Globetronics and Intel have expanded their operations in Penang tremendously. Agilent has expanded its subsidiary with new buildings in 2001, 2002, 2003, 2008 and 2013. The main reason for Agilent was to increase its R&D functions. For Globetronics, the main reason for its expansions in 2005, 2007, 2010 and 2011 was that it was differentiating its product portfolio towards LEDs, while maintaining its semiconductor division. In 2013, Intel opened its newest chip design center in Penang, which is the firm's largest subsidiary outside the US. For the other subsidiaries, the main reason to expand was to increase their initial production capacity or to add a new product line.

From all the subsidiaries in the sample, AMD stands out since it is the only subsidiary that decreased its operations in Penang. Following a strong demand crash for personal computers and laptops in 2010 and 2011, it decided to close down one of its 2 Penang factories. However, the HQ is still committed to Penang as is shown by the subsidiary's new charter. The Penang subsidiary is the only subsidiary assigned to produce all CPUs and APUs for the Playstation 4 and XBOX One. However, Penang was not assigned any R&D functions. For its R&D, AMD remains largely committed to the US, but the firm also has R&D facilities China, India and Taiwan.

6.4.3 Other Southeast Asian regions

For a subsidiary like AMD it is interesting to see why the HQ prefers other regions over Penang with respect to R&D. According to the interviewee, investments in improvement of the CPU and APU hardware are very expensive. At the same time, the production process is largely standardized, so R&D on hardware development will not be put into practice until next product generations are produced. The investments will only pay out on the long term. Meanwhile, there is still a large performance gain possible by improving firmware (such as the drivers). Unfortunately for Penang, software development is

a weakness of the region. According to the interviews, compared to regions such as Bangalore, Shanghai and Singapore, Penang is lagging far behind. Therefore, in AMDs production network, the firm trusts Penang with hardware matters, but assigns software development to subsidiaries in other regions.

This lack of software skills in Penang was also recognized by Agilent, Benchmark and sTec. However, for their R&D they do not depend as much on software development as they do on hardware development, so these subsidiaries judge Penang as better than other regions in Southeast Asia. The main benefits of Penang are the supply of cheaper talented labor compared to Japan, Singapore, Taiwan and obviously the European Union and the US. China's major weakness is its unpredictability. This is not just the opinion of Agilent and sTec, but confirmed by most MNC subsidiaries. The labor costs have risen disproportionately, which makes China now more expensive than Penang. Particularly when MNCs are trying to develop a long-term strategy, Penang is more favorable, because of its political stability and higher certainty.

Other benefits of Penang are (especially for European or US-based MNCs) that most Malaysians speak English. Therefore, there is no language gap between managers and workers. Some subsidiaries also indicate the living environment as one of Penang's major assets. The cultural amenities in Penang are to be found nowhere else in Southeast Asia. In a minority of cases, respondents of Japanese and Taiwanese subsidiaries perceived their country of origin as a better region than Penang, especially its technology – and supply base.

6.5 Interpreting charter development: corporate RPNs

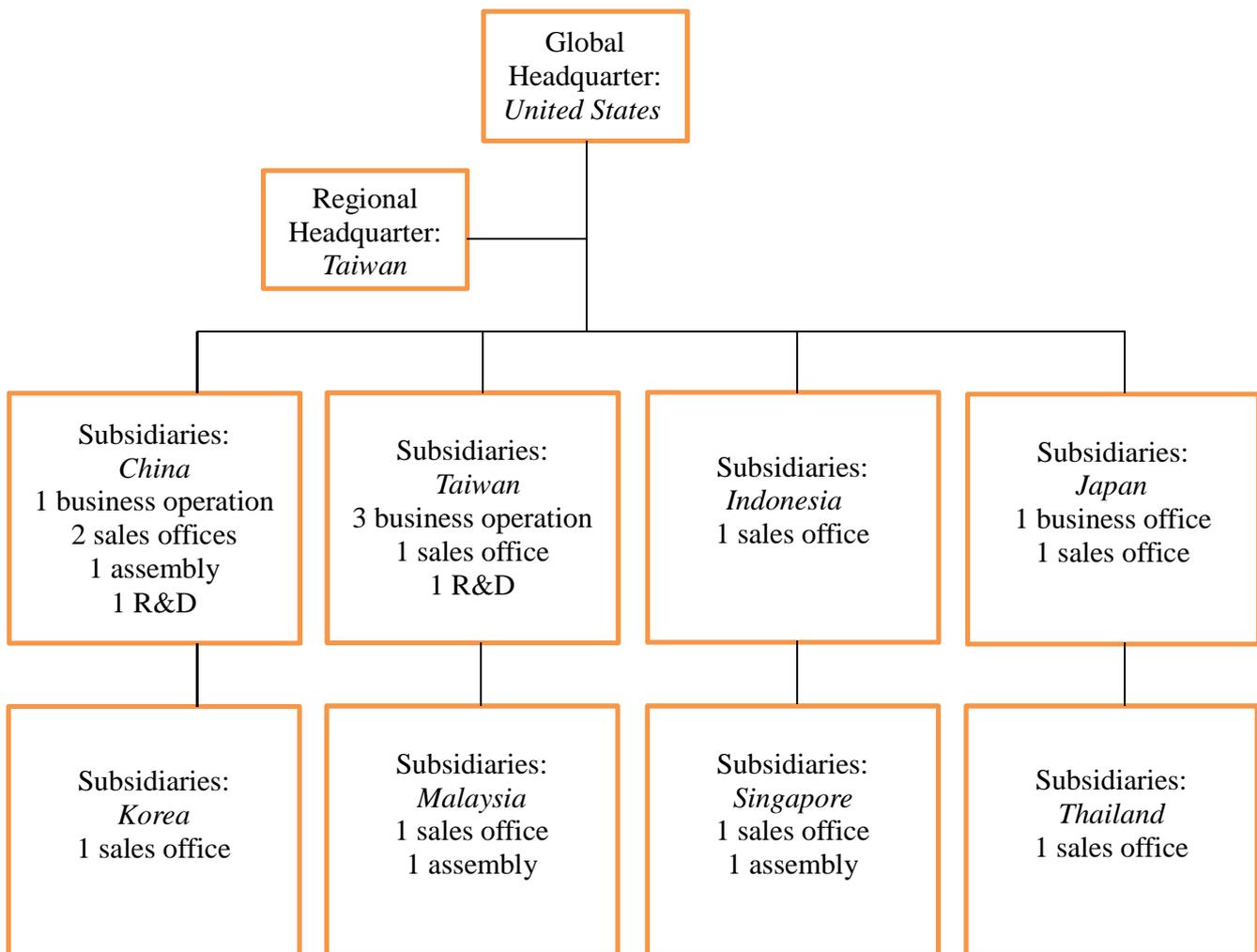
As mentioned in Chapter 2, the global strategy of an MNC encompasses a network of subsidiaries also referred to as the RPN. This section will take a closer look at the global strategy of an MNC and how this determines the charter of the subsidiaries in its RPN. First, this section gives insight in how an RPN is shaped, illustrated by an example of AMD. By means of this example, the current situation and the development of this RPN of the other MNCs in Penang will be described. The second section will take a closer look at competition and collaboration within the RPNs and how this has influenced the position of the subsidiaries. Finally, as an indication for the shape of the RPN, the third section will discuss the subsidiaries' capabilities and how they have changed throughout the years.

6.5.1 Position within the RPN

One of the aspects determining the activities of a subsidiary is its charter, assigned by the HQ (or RHQ) of the MNC. The level of autonomy of a subsidiary depends on the subsidiary's position within the RPN of the MNC (and, indirectly, on the characteristics of the region as elaborated on above). The position of a subsidiary in the RPN may as well change over time as the factors determining it are dynamic.

Figure 6.2 below gives an impression of the RPN of AMD in 2013. The RPN is constructed based on the interview (Yoo, 2013), supplemented by information from the website of AMD (2013). The figure of AMD's RPN shows a schematic view of the different components of its RPN. The HQ is located in the US in Sunnyvale, California. Additionally, AMD also has business operations – establishments with an RHQ function – in China, Japan and Taiwan. Officially, the regional HQ for AMD in Penang is Taiwan (Taipei), however the interviewee indicated that the Penang subsidiary reported directly to the HQ in the US.

Figure 6.2: The Southeast Asian production network of AMD in 2013.



Source: Interview Yoo, 2013; AMD website, 2013 (edited)

As figure 6.2 shows, AMD has merely two operations in Malaysia: a sales office in Kuala Lumpur and a manufacturing facility in Penang. For its R&D, AMD trusts mainly on the US and India. However, it has a considerable amount of operations in Taiwan (in Hsinchu, Koahsiung and Taipei) and China (in Beijing, Hong Kong, Shanghai, Shenzhen and Suzhou) among which are also R&D functions. Although figure 6.X suggests a certain hierarchy within Southeast Asia, the AMD respondent indicated that the Penang subsidiary operates fairly independent. Most smaller decisions on operational matters are made locally in Penang, while major decisions on investments or function allocations are made by the HQ in the US.

The dominance of China in the Southeast Asian RPN of AMD was also acknowledged by respondents of the other MNC subsidiaries. On average, the MNCs in the sample have about 4.3 subsidiaries in China. However, the subsidiaries are widely dispersed among different regions in China. It must also be noted that Cisco and Robert Bosch skewed the average, as they have respectively 39 and 20 subsidiaries in China. Furthermore, most of the subsidiaries in China are manufacturing facilities with a production function. As Penang is in need of upgrading towards more value-added functions, the major competing regions in China are Beijing, Hong Kong, Shanghai and Shenzhen.

On average, the MNCs in the sample have 1.9 subsidiaries in Penang. The high participation of MNCs in Penang is mainly caused by Eng Teknologi, Globetronics and Intel, which together account for about 38 percent of all MNC subsidiaries in the region. In order of subsidiary occupancy, other countries incorporated in the RPN of MNCs in Penang are Japan, Singapore, South Korea, Thailand, Taiwan, the Philippines, Indonesia and Vietnam.

Cisco, Intel and Robert Bosch are the MNCs with the most extensive RPN. Intel has 35 subsidiaries in Southeast Asia, while Cisco and Robert Bosch have more than 50 each. For Cisco, China is its most important manufacturing location, while it deploys its R&D activities mainly in Japan, Singapore and South Korea. As Penang has recently become an RHQ for Cisco, it has been assigned the task to manage and integrate the production and R&D processes in the Southeast Asian RPN. Intel Penang is also an RHQ for the APAC-region, but deploys R&D functions as well. For Robert Bosch, R&D functions are primarily located in Germany, Japan and South Korea and to a lesser extent also in China.

Changes within the RPN

With respect to changes within the RPN, for just 3 MNCs in the sample the amount of subsidiaries has declined. More than half of the MNCs have increased operations. Robert Bosch indicated that since the ASEAN-region is emerging, it is expanding its operations in the region to improve local service. Most MNCs indicated to have increased their operations in Penang/Malaysia. Another growing region, although not located in Southeast Asia, is India. Especially for software development purposes, India is a popular destination for MNCs. In the interviews it was also remarkable that while some respondents indicated that the amount of subsidiaries in China had increased, just as many respondents indicated that for their MNC China operations were declining. As some MNCs choose to move low-cost production to China, others consider the country to be too unpredictable and unstable. These MNCs rather return to an environment that is safe in their opinion such as Penang, with more political stability and without language barriers.

Intra-firm competition and collaboration

Regarding China's size and relative low labor costs, it is not too surprising that most MNC have subsidiaries here. However, it is interesting that despite the large amount of subsidiaries in China, most of the MNC subsidiaries in Penang did not perceive China as their major competitor within the RPN. If any, the countries in Southeast Asia that were considered to be major competitors for the Penang subsidiaries were Singapore and other regions in Malaysia (Johor and Kuala Lumpur). During the interviews it was remarkable that most MNC subsidiaries rather perceived the HQ in their home country as a challenging competitor than subsidiaries in Southeast Asia. Especially the large US-based MNCs Agilent, Altera, Intel and sTec regarded the HQ as their major competitor.

Overall, just about one third of all respondents felt that the relationships between the different subsidiaries in their RPN are competitive. Most respondents experienced the relations rather cooperative than competitive. This cooperation is mostly expressed in mutual collaborations as a result of top-down decisions regarding the division of activities within the MNC. In most cases, the division of activities is based on production and R&D allocation matters.

In the interviews, all but one respondent considered the relations between the Asian subsidiaries of their MNC to be at least important. Most respondents even perceived them as very important. So for the MNC, the links between its nodes in the RPN are valuable according to the interviewees. With respect to other subsidiaries in the RPN, the majority of the respondents felt that the position of their subsidiary was strong to very strong. For more than 85 percent of the respondents the position of their subsidiary towards the HQ or RHQ was strong to very strong. However, as became evident during the interviews, a low(er) perception by the interviewee of its subsidiary's position within the RPN does not necessarily mean less charter.

Capable to improve the position within the RPN?

In the section about product upgrading, the respondents were asked about whether the products they make in their subsidiaries is new for the market as a whole. Additionally, they were also asked if the product they make is new for the firm as a whole. While the former tells something about the innovativeness and sophistication of the products, the latter gives insight in the responsibilities of a subsidiary assigned by the HQ and its position within the RPN.

Remarkably, over two third of the respondents indicated that their subsidiaries made products that are entirely new for the firm. For example, the AMD subsidiary in Penang indicated that they are the only subsidiary globally to produce CPUs and APUs for the new Playstation 4 and XBOX One gaming consoles. The trust in the manufacturing capabilities of its Penang subsidiary is quite high if the HQ gives it such a responsibility. However, apparently the trust in capabilities was not strong enough to also assign R&D functions to this subsidiary.

Regarding the dynamic nature of the responsibilities of subsidiaries, the respondents were also asked whether their subsidiary had taken any initiatives on its own to improve their charter. As 65 percent indicated that they had taken such initiatives, these initiatives did not always actually result in a better position. Furthermore the nature of these initiatives was very diverse. For AMD, which had been struggling, the initiatives were based on cost-cutting activities. For Agilent on the other hand, the initiatives focused on improving the subsidiary's in order to play a pivotal role in the RPN (which in the end have proven to be successful). At the Altera subsidiary in Penang, the initiatives were mainly pointed towards more autonomy with respect to R&D functions, as they wanted to develop a new flagship product in Penang, independent of the US. Although in some cases the Penang establishment already had HQ or RHQ functions, subsidiaries nevertheless took initiatives both to maintain and improve their position.

6.5.2 Factors influencing the RPN

Looking back at the theories on decision-making processes discussed in the theoretical framework, they suggest that if a subsidiary wants more charter and a better position, this requires sufficient capabilities to execute these new responsibilities. Surprisingly, according to the respondents, the most important factors determining the responsibilities of a subsidiary are: (1) past performance of the subsidiary, (2) growth potential of the market, (3) range of competencies of the establishment, (4) position with respect to other subsidiaries within the RPN, (5) locational factors of the subsidiary's region. Although the respondents feel that their performance and market potential make the largest contribution to their responsibilities, it requires certain capabilities to perform and serve a growing market. Therefore, it is interesting to see how the interviewees qualify the capabilities within their subsidiary. The capabilities of a subsidiary can be divided into: production capabilities, technological capabilities and marketing capabilities.

As production is divided into low, medium and high level production, these levels of production are not applicable on all subsidiaries. Just about half of all subsidiaries indicated the categories low and medium production to be relevant. These subsidiaries were extremely positive about their low-level capabilities and positive about their medium-level capabilities. At the same time, the majority of the subsidiaries indicated to be involved in high level production and they considered it to be slightly better than good.

Regarding technological capabilities, there is a distinction between technology absorption and creation. Furthermore, there is a distinction between product and process technologies. In practice, this distinction is more to enhance the understanding of different technological capabilities than that it is helpful as a guideline to interpret the results since the outcome of the interviews shows that the perception of technological skills regarding products and processes are highly similar. In the interviews 25 subsidiaries indicated they absorbed product and process technologies and on average they

perceived themselves good at it. Although just about half of the subsidiaries in the sample were involved in the creation of product and process technologies, they were even slightly more positive.

With respect to sales/marketing, subsidiaries can be involved in client liaison, client procurement and flexibility towards clients. As the subsidiaries are relatively positive about their liaison and procurement capabilities, of all the capabilities they are most satisfied about flexibility towards clients. The high perception of their flexibility is related to the fact that about 70 percent of the subsidiaries in the sample indicated to be (partly) involved in Original Equipment Manufacturing (OEM), which requires high flexibility.

6.6 Future prospects

How does the near future look for subsidiaries in Penang? Will they expand or downstream their businesses upgrade their functions or gain a better position within the RPN? As the interviews clarify nearly every subsidiary is confident that their product line(s), their activities and the quality of their products and processes will increase within the next 5 years. Besides this shared view of the future half of all interviewed subsidiaries believe that their position in the MNC will increase as well. The remaining half is confident that their position will be unaltered, mostly because they already have a strong position.

Having a closer look the majority of the smaller MNC subsidiaries, Goodwill Instruments, Elamp Precision and Bizlink have indicated to expand physically in the near future, increase their product volume and acquire more customers. The larger MNC subsidiaries like Agilent, Intel, AMD and Cisco focus more on steady growth and more value adding accompanied by less total output of products. All subsidiaries foresee a bright future in Penang.

6.7 Conclusion

The industrialization of Penang started with the establishment of branch plants with little more than a production function for the HQ. As countries such as Cambodia, China and Vietnam have a competitive edge over Penang in terms of low-cost labor, MNCs seem to move the labor-intensive production activities away from Penang. In light of these developments, and increasing competition of other Southeast Asian countries, Penang has to move into higher value-added functions such as R&D to remain competitive as a region. However, in the higher segment of functions, Penang meets new competitors. As Penang seems to be lagging behind, in chapter 3 the following hypotheses have been constructed with respect to upgrading of functions, products, processes and charter:

Between 2004 and 2013, functions, products and processes within MNC subsidiaries in the E&E industry in Penang have downgraded.

Between 2004 and 2013, the charter of MNC subsidiaries in the E&E industry in Penang has decreased.

This chapter has shown that in the past 10 years, particularly because of a strong increase in R&D activities, most subsidiaries have upgraded their functions towards more sophistication. Considering the relocation of production activities to low-cost countries, average functional upgrading in Penang could be a result of this corporate strategy. However, instead of declining, the production function remains the most important function in Penang. Nonetheless, internally several MNC subsidiaries – mainly US-based – have strongly increased their focus on R&D by attracting high-skilled workers and expanding their premises with R&D centers.

Besides their functions, MNC subsidiaries in Penang have also upgraded their products and processes. All subsidiaries indicated that the sophistication and complexity of their products has increased. In some cases upgrading of products may be inherent to the pace of technological developments. However, some MNC subsidiaries are also involved in producing new products for the

market. These are especially subsidiaries of large MNCs with more than 1.000 employees, but also smaller MNC subsidiaries make products that are new for the market. As they have shifted their functions towards R&D and upgraded their products, MNC subsidiaries in Penang have been seeking higher-skilled personnel. For production functions, the processes have become more automated with high investments in sophisticated machinery. In case a subsidiary does not deploy R&D activities, usually the workforce is rather low skilled. For subsidiaries with R&D functions, investments in high-skilled workers are very important. Although R&D requires sophisticated machinery, investments in high-skilled labor exceed the relative investments in machinery.

Related to the change in functions, products and processes described above is the development of a subsidiary's charter. The responsibilities of a subsidiary can vary among different domains. As there are quite a few subsidiaries with an HQ or RHQ function in Penang, these subsidiaries have responsibilities on all domains within their own subsidiary and sometimes they also make decisions for other subsidiaries. Especially the amount of RHQs in Penang has increased in the past 10 years.

As the first 2 hypotheses have been rejected, it is interesting to see what factors have been conducive to upgrading and what makes Penang attractive for MNCs. Because the literature was reserved about the quality of the regional characteristics of Penang, the next hypothesis has been constructed:

Between 2004 and 2013, less locational commitment of MNCs in the E&E industry in Penang is caused by the degeneration of Penang's regional characteristics.

Looking at the results in this chapter, this hypothesis can be rejected. The most important factor for upgrading is the availability of affordable and high-skilled labor. Following the interviews, this is the main asset of Penang. The quality of labor is good and especially the costs of high-skilled personnel are low compared to other regions in Southeast Asia. For subsidiaries of smaller MNCs, it can sometimes be challenging to attract skilled workers, but for large MNCs this does not seem to be an issue at all. With respect to skills, the only problem in Penang is the lack of software engineers.

The infrastructure in Penang is well organized, despite traffic jams during the commuting hours. The technology base in terms of research institutions is not very strong, but MNCs base their upgrading decisions on their own technology development capabilities, which they qualify as sufficient. The supply base in Penang is fairly strong, although not as good as in regions in Japan and Taiwan. Overall, MNC subsidiaries seem to be reasonably well-embedded in Penang, especially in engagement in institutions. As most subsidiaries are mainly export-orientated their clients are usually located outside Penang.

The government is an important actor for MNC subsidiaries, although favorable institutions are more a prerequisite for upgrading rather than conducive to upgrading. MNCs require a certain level of stability; in case of technological breakthroughs they have to be able to protect these technologies by filing patents. Furthermore, the political climate has to be predictable for planning future strategies. In addition, incentives can contribute to upgrading decisions, but are not of vital importance. With respect to living environment, Penang seems to be a favorable region. However, congestion and availability of housing are becoming an issue.

Now the first 3 hypothesis on the subsidiary level have been rejected, the question arises how this influences the final hypothesis. This hypothesis was based on the assumption that the regional characteristics in Penang would have been deteriorating in the past 2 decades, resulting in less locational commitment by MNCs. The hypothesis as formulated in chapter 3, is described below:

Between 2004 and 2013, a weaker position in the RPN of MNC subsidiaries in the E&E industry in Penang is caused by less locational commitment of MNCs to Penang.

In contrast to the assumption that the regional characteristics have deteriorated, this chapter described that the Penang region has improved. It has been confirmed that there is a relation between locational commitment of MNCs and the position of subsidiaries within the RPN. However, the negative relation in this hypothesis can be rejected, as MNCs have become more committed to Penang. Overall, Penang is judged as a more favorable region compared to other regions in Southeast Asia. This commitment is also illustrated by past investments in local expansions. Furthermore, the relationship between the position in the RPN and locational commitment seems to move in 2 directions. More commitment leads to a better position in the RPN, while on the other hand a better position in the RPN results into more commitment.

According to the findings described in this chapter, the literature on the regional characteristics of Penang is rather negative. This chapter has shown that MNCs view Penang as a favorable region for upgrading of functions, products and processes. Commitment has increased and subsidiary charter has expanded. However, it is hard to judge whether Penang has experienced considerably more upgrading than other regions. A similar study in other regions in Southeast Asia would be interesting as this would give the opportunity to make a comparative analysis of upgrading in the regions.

Chapter 7: upgrading in the Penang region?

7.1 Context

In the introduction of this thesis is described how Penang was industrialized and how its E&E industry has developed rapidly from the 1970s to the 1990s. With China opening its borders in the 1990s and increasing competition of regions in other countries such as Cambodia and Vietnam, Penang seemed to be losing its competitive edge in terms of labor costs. Penang had to move up the value-chain to remain attractive for MNCs, which included a transformation from production to more value-added functions such as R&D. However, this transformation is challenging and depends on numerous factors. To attract MNC subsidiaries with R&D functions, Penang would be competing in a completely different league, with regions that are already more advanced. The question whether or not Penang has been capable of upgrading its E&E industry, has led to the following research question:

“How has the electronics and electrical industry in Penang evolved in the past two decades and how can this be explained?”

As answering the main research question in one breath would be rather complex, the question is divided into 2 levels of analysis, the industry level and the subsidiary level. The corresponding sub-questions are presented below:

Industry level

- *How have MNC subsidiary entries and exits between 1994 and 2013 altered the composition of the E&E industry in Penang?*
- *To what extent have MNC subsidiary entries and exits between 1994 and 2013 in the E&E industry in Penang resulted in the emergence of new branches?*
- *To what extent does the evolution of the E&E industry in Penang between 1994 and 2013 reveal up- or downgrading?*

Subsidiary level

- *How have MNC subsidiaries in the E&E industry in Penang evolved between 2004 and 2013?*
- *Which regional characteristics have been conducive to upgrading in Penang between 2004 and 2013?*
- *How has the Southeast Asian network of subsidiaries of MNCs in the E&E industry in Penang changed between 2004 and 2013?*
- *With the results from these questions, how can recent policies focused on upgrading of the E&E industry in Penang be evaluated?*

Before answering these questions, chapter 2 showed the relevant theories on concepts such as branching, upgrading, charter development and regional production networks of MNCs. These subjects are useful for the analysis of industry and subsidiary evolution and from these theories, the conceptual model was derived. Chapter 3 presented an overview of the regional characteristics of Penang, according to recent literature. Based on the conceptual model and the regional characteristics, several hypotheses have been constructed, divided in the industry level and the subsidiary level. After the theoretical framework and the regional characteristics, in chapter 4 discussed the data sources and methods used in this research and which restrictions this implied. Chapter 5 covered the industry level analysis, while the subsidiary level was described in chapter 6.

7.2 Conclusion

As the sub-questions have been answered throughout this thesis, it should now be possible to answer the main question of this research:

“How has the electronics and electrical industry in Penang evolved in the past two decades and how can this be explained?”

At the industry level analysis in chapter 5, the composition of the E&E industry in Penang was analyzed. With the established MNC subsidiaries in 1994 as a starting point, entries and exits between 1994 and 2013 changed the composition of the industry. This changing composition was based on the concept of branching out.

In the period 1994-1998 the E&E industry still experienced rapid growth. In this period, the first MNC subsidiaries involved in manufacturing SSDs and computer hardware entered Penang. After 1998, especially the HDD branch experienced a sharp decline, which might have been an aftereffect of the Asian Crisis in 1997. From 2004 onwards, the growth of the E&E industry in Penang started to slow down. Especially after the global financial crisis in 2008 the growth stagnated.

However, some MNC subsidiaries still entered Penang in the final period. The SSD branch has emerged and MNC subsidiaries manufacturing semiconductors and LEDs have entered Penang. LEDs and semiconductors have become more sophisticated and the HDD branch – which is less sophisticated than the SSD branch – has declined. Meanwhile, internally the audio equipment branch has become more sophisticated, as the subsidiaries have upgraded their products from traditional audio equipment to mobile entertainment and media systems.

As the industry level analysis has shown, overall, the E&E industry in Penang did experience upgrading between 1994 and 2013. New branches and branches that have expanded are more sophisticated than the branch that has declined the most: the HDD branch. However, at the industry level, it is hard to judge whether the changed composition of the E&E industry in Penang is a result of global technological change, or a truly favorable business climate in Penang. Furthermore, the growth of the E&E industry seems to have stagnated. This might be an indication that policies should look further than trying to attract new MNCs. The years of exogenous implantation, which have proven successful in the past, do not seem to be feasible on the long run.

At the subsidiary level, the majority of MNC subsidiaries has upgraded between 2004 and 2013. Especially by increasing their R&D function, MNC subsidiaries upgraded their functions. All MNC subsidiaries have upgraded their products and most of them have upgraded their processes. In some cases their charter has increased significantly and their position in the RPN improved accordingly. The regional characteristics in Penang have been favorable for upgrading, especially with respect to the availability and costs of skilled labor. However, for some MNCs the lack of software skills in Penang has refrained them from upgrading. Government stability and predictability are both prerequisites for upgrading.

Although many MNC subsidiaries have upgraded their functions, production remains the most important function. Furthermore, as this is not a comparative study about upgrading in other regions, it is difficult to interpret upgrading in Penang. It is hard to judge whether the upgrading path of MNC subsidiaries exceeds that of subsidiaries in competing regions and whether Penang is catching-up or still lagging behind.

However, the fact that MNC subsidiaries in the E&E industry in Penang have upgraded still is a positive sign. Therefore, for Penang the major problem does not so much seem to be the lack of

upgrading, but the lack of new MNC subsidiaries entering the region. While in the past MNCs brought employment and eventually wealth to Penang, the inflow of MNC subsidiaries seems to stop. On the long run, the lack of new entries might result in unemployment among the population. An obvious solution would be entrepreneurship, but with the highly MNC-centralized policies, entrepreneurship in Penang might not have come off the ground that easily. Therefore, further research on topics such as the evolution of local firms (without any foreign subsidiaries) would be a valuable complement to this research.

7.3 Discussion

A first limitation of this research is imposed by the definition of the research unit, in this research: MNC subsidiaries in the E&E industry in Penang. This group was selected, because the research had to be realized in a period of 5 months. However, following this restriction, the results described in this thesis are only applicable on MNC subsidiaries. To get a better view of the developments within the industry, in future research all firms in the E&E industry in Penang could be included.

A second limitation did become clear after the collection of the data at the industry level. All data sources combined still left a gap in the data between 2005 and 2010. Linking the 2004 and 2011 data did provide insights in the subsidiaries that remained in Penang, but MNC subsidiaries that entered Penang after 2004 and had already left by 2011 could not be included. Furthermore, information about the main products of the subsidiaries was only available for 1997 through 2004 and for 2011 and 2012. The missing data for the period 1994-1997 and the gap between 2004 and 2011 did not allow for a complete analysis of changes within the product groups. Although the comparison between 1997 and 2012 did not reveal many product changes within subsidiaries further research on this topic would be interesting to see how the products within the branches may or may not have upgraded.

The interviews at the subsidiary level analysis were also quite challenging. Although many respondents replied very cooperative to the interviews, unfortunately not all MNC subsidiaries were equally willing to participate. In some cases, the timespan of the 2 months in which the interviews had to be conducted simply turned out to be too ambitious as the responsibilities of the respondents left them with tight schedules. Therefore, the opinion of several important MNCs in the E&E industry in Penang such as Avago, B Braun, BenQ, Dell, Fairchild, Lumileds, Motorola, Osram, Renesas, Seagate and Sony is missing in the analysis. Furthermore, a higher response rate would increase the external validity of this research.

However, despite the limitations and issues with respect to the interviews, the authors of this thesis hope that their efforts have led to valuable insights in (the mechanisms behind) the evolution of the E&E industry in Penang.

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Appendix I : Questionnaire

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Study on the development of the Electrical & Electronics (E&E) industry in Penang

Subsidiary name:

Name of respondent:

Job title of respondent:

Subsidiary address:

Telephone number:

Company website:

I. General information

1. Year of establishment of this subsidiary
2. What is the investing company of this subsidiary?
3. Is the investing company also the parent company of this subsidiary?
 Yes (please proceed to question 4)
 No (please proceed to question 5)
4. If yes, what is the location of the parent company?
5. If no, what is the status of the investing company? (e.g, Sub/regional HQ/)
.....
6. What is the parent company of this subsidiary?
7. According to our registration this subsidiary is wholly foreign owned. Is this correct?
 Yes No, ownership status.....

8. What kind of investment of the investing company would you consider this subsidiary to be?

- Greenfield investment
- Acquisition of another firm
- Joint venture
- Other,

9. Has this establishment operated under other names previously?

- Yes No

10. If indicated "yes", under what name(s) has this establishment previously operated?

.....

11. To what unit within the company does this subsidiary/establishment report?.....

12a. How many people does this establishment currently employ?

12b. Have there been any significant changes in the number of employees over the past 10 years (if established less than 10 years ago, since establishment)?

- Yes, an increase
- Yes, a decline
- No

12c. If yes, when and what was the main reason for this increase/ decline?

.....

13. What would you consider to be the core business of the parent company?

.....

II. Evolution of the subsidiary

14. Please indicate the functions of this establishment and changes therein since start

Short intro

	Production	R&D/ D&D	Procurement of materials	Sales/ marketing	Management	Other (please specify)
Current						
Year:						
Year:						
Year:						
Year:						

Year:						
Start						

Note: D&D = Design and Development

- If indicated that the establishment is currently NOT involved in production anymore please proceed to question 15.

- If indicated that the establishment is currently involved in production please proceed to question 17.

Products

15. What were the prior products that have been produced, right before closing down production?

.....

16. Why has it been decided to close down production operations?

- The former product no longer part of the product portfolio of the company
- The former product replaced by a new generation that is produced elsewhere
- Production has been outsourced
- Production was moved to other locations, because of:
 - Market reasons
 - Costs
 - Consolidation
 - Other.....
- Other, such as:

17. Currently, the main product(s) of this subsidiary is/are:

18. Has the production volume changed over the past ten years (or since establishment)?

- Yes, increased
- Yes, decreased
- No

19. Have there been any changes in the product portfolio of this subsidiary over the past 10 years (or since subsidiary establishment)?

- Yes (please proceed to question 20)
- No (please proceed to question 24)

20. If yes, please indicate these changes, when these changes occurred and the reason

	Products	Reason for the change
Current		
Year:		
Year:		
Year:		
Start		

21. At time of implementation, was the main product manufactured in this establishment new for the parent company?

Yes No

22. At time of implementation, was the product manufactured in this establishment new for the market?

Yes No

23. Would you consider the change in the product portfolio over the past ten years (or since establishment) to be:

From lower to higher-end

From higher to lower-end

No significant change

 From lower to higher complexity

From higher to lower complexity

No significant change in complexity

 From more specialized to less specialized

From less specialized to more specialized

No significant change

Processes

24. What is the composition of employment in this subsidiary?

	100 / 76 %	75 / 51%	50 / 26%	25 / 0%
High skilled employees / Low skilled employees				
Technicians / assembly workers				
Foreign employees / Local employees				

25. Please indicate the share of engineers in total employment of this establishment:%

26. How would you consider the following in this subsidiary?

	High	Medium	Low
Investment in machinery versus labor			
Level of sophistication of machinery			
Level of automation of the production process			

27a. What is the dominant trend in these indicators?

.....

.....

.....

27b. Could you please explain the answer to question 27a? (E.g, Labor costs; Overall labor availability; Availability of high skilled employees; Product-driven change (higher technology content of new products))

.....

.....

Technology, Research & Development

28. How do you acquire new technologies?

a. Products

- From the HQ
- From other subsidiaries
- From clients
- Own R&D
- By imitating / copying other firms (acquisition other firms)
- Other (specify)

b. Processes

- From the HQ
- From other subsidiaries
- From clients
- Own R&D
- By imitating / copying other firms (acquisition other firms)
- Other (specify)

Answer questions 29-31 ONLY if indicated in question 14 that currently R&D/D&D is carried out in the establishment

29a. If involved in R&D/D&D activities, what kind of activities are executed by this subsidiary?

- New product development
- New production process development
- Product adaptation
- Production process adaptation
- Other, such as:

29b. What percentage of your labor force is currently involved in R&D? %

29c. Has this percentage R&D workers changed over the last ten years (or since establishment)?

- Yes
- No

If indicated "yes", how has this percentage changed?

- Strongly increased
- Slightly increased
- Slightly decreased
- Strongly decreased

29d. What would you consider to be the main reason for this change in the percentage of R&D workers?

.....

30. Is this establishment involved in the filing of patents?

- Yes No (please proceed to question 33)

31. If yes, how important would you consider these patents to be for the parent company?

- very important
- important
- neutral
- unimportant
- very unimportant

Answer question 32 ONLY if indicated in question 14 that currently no R&D/D&D is carried out in the establishment, but such activity was in the establishment earlier.

32. If this subsidiary used to be involved in R&D, but not anymore, why were R&D activities stopped?

- Another subsidiary is now responsible for the R&D activities
- Not enough human capital available anymore
- Consolidated by the HQ
- Not enough local support institutions
- Other (specify)

Markets

Answer questions 33 and 34 ONLY if indicated in question 14 that currently marketing is carried out in the establishment

33. What percentage of you labor force is currently involved in marketing activities? %

34. Do your marketing activities involve (multiple answers possible):

- Maintain relations with established clients
- Acquisition of new clients
- Explore new markets
- Other, such as.....

35. Who do you consider to be your most important clients?

.....

Expansion

36. According to our understanding your subsidiary has applied for an approval in the year(s) [insert year:]. What were your objectives for applying for this approval?

.....

37. Have the premises of this subsidiary physically expanded over time?

- Yes, expanded on the same location (please proceed to question 38)
- Yes, expanded to a different location (please proceed to question 38)
- No (please proceed to question 40)

38. In what year(s) has this physical expansion taken place?.....

39. What would you consider to be the main reason(s) for this/these expansion(s)?.....

.....

Capabilities

40. What would you consider to be the main focus of your product portfolio?

- OEM
- ODM
- OBM

41. How would you qualify the following capabilities of this establishment?

Production

Low end	high	5	4	3	2	1	low	NA
Mid end	high	5	4	3	2	1	low	NA
High end	high	5	4	3	2	1	low	NA

Absorption new technology

Product	high	5	4	3	2	1	low	NA
Process	high	5	4	3	2	1	low	NA

Creation new technology

Product	high	5	4	3	2	1	low	NA
Process	high	5	4	3	2	1	low	NA

Marketing

Client liaison	high	5	4	3	2	1	low	NA
Client procurement	high	5	4	3	2	1	low	NA

Flexibility (client specifications) high 5 4 3 2 1 low NA

Other (specify) high 5 4 3 2 1 low NA

42. Can you elaborate on the learning processes in the establishment (multiple answers possible)?

- Intra-company protocol transfer
- Intra-establishment labor training
- Intra-establishment protocol development
- Recruitment of specifically skilled labor
- Participation of workers in labor training institutions (such as PSDC)
- Participation in government programmes, aimed at Human Resources
- Industry seminars/conferences (e.g. organized by association)
- Other (specify)

What is the most important way of learning in the establishment?

.....

43. Capabilities in this establishment related to the value chain are rather deep

- Agree Disagree

44. Capabilities in this establishment related to the value chain have a rather wide scope

- Agree Disagree

45. What would you consider to be the key asset(s) to profitably operate in Penang:

.....
.....

46. Has this establishment obtained quality control certificates?

- Yes (please proceed to question 47)
 No (please proceed to question 49)

47. If yes, please indicate which certificates:

- ISO 9000 (International Organization for Standardization)
 ISO 14000 (International Organization for Standardization)
 SQC (Statistical Quality Control)
 TPM (Total Preventive Maintenance)
 TQM (Total Quality Management)
 QCC (Quality Control Circles)
 MRP (Materials Requirement Planning)
 MRPI (Materials Resource Planning)
 MRPII (Integrated Materials Resource Planning)
 JIT (Just In Time)
 Other, specify:

48. How important would you consider the certificates to be regarding your capabilities?

.....
.....

.....

III. Local environment and other local drivers

49. Which of the following regional characteristics do you perceive as important for the functioning of the establishment and upgrading? How do you evaluate each of the characteristics?

Indicator		Importance					Evaluation
		1	2	3	4	5	
Labor	Volume						
	Costs						
	Skills						
	Training institutions						
Technology base	Other companies						
	Research institutes						
	Educational institutes						
	Government technology programs						
Infrastructure	Physical						
	ICT						
	Knowledge						
Connectivity	International						
	National						
	Regional						
Supply base	Quality of local suppliers						
	Diversity of local suppliers						
Government Federal	Efficiency						
	Policies & incentives						
	Pro-activeness						
	Political stability						
	Interaction potential						
Government State	Efficiency						
	Policies & incentives						
	Pro-activeness						
	Political stability						
	Interaction potential						
Living environment	Pollution						
	Congestion						
	Crime						
	Cultural amenities						
	Housing						
	Health-care facilities						
	Schooling						

Importance: 1 = Very important, 2 = Somewhat important, 3 = Neutral, 4 = Unimportant, 5 = Very unimportant

Evaluation: 1 = Excellent, 2 = Good, 3 = Fair, 4 = Bad, 5 = Very bad

50. What is your perception of recent changes (in the past 5 years) in the overall regional environment?

- Much improved
- Improved
- No change
- Worse
- Much worse

51. Has any of the above indicators played a major role in the (lack of) upgrading of this establishment?

- Yes
- No

52. If yes, which indicators(s)?

.....

53. If no, what other factors have been at play?

.....

54. How do you compare Penang with other regions in Asia where your company operates as to local environment?

.....

.....

.....

55. Is your establishment currently engaged in local public-private partnerships, and if so: in which?

.....

.....

.....

IV. Position of the establishment in the firm (RPN): corporate regional network and corporate/establishment strategy

Asian corporate network (listed in appendix)

56. Has the number of subsidiaries in Asia changed over the past ten years (or since establishment)?

- Yes, the number of subsidiaries has increased

- Yes, the number of subsidiaries has decreased
- No, the number of subsidiaries has remained equal

57. Have there been shifts between countries?

- Yes
- No (proceed to question 60)

58. Countries that have experienced an increase:

.....

59. Countries that have experienced a decline:

.....

Responsibilities

60. Where are decisions made about:

Item	HQ	RHQ	Subsidiary	Other,
Allocation of product lines				
Product portfolio				
Process changes				
Functions (e.g. R&D)				
Procurement materials				
(Resolution of) operational matters				

61. Can this establishment make decisions autonomously?

- Yes (proceed to question 62)
- Occasionally (proceed to question 62)
- No (proceed to question 64)

62. If yes (or occasionally), on what domains can the establishment make decisions?

.....

63. Have there been any changes in the level of autonomy?

- Yes, it became larger
- Yes, it became smaller
- No

64. What factors would you consider to determine the level of autonomy within the company for this establishment?

- Performance of the establishment
- Range of competencies of the establishment
- Growth (potential) of the market
- Position with respect to other subsidiaries
- Locational factors of the establishment's region
- Other, such as:

Intra-company subsidiary competition

65. Do you feel that subsidiaries:

- Compete with each other (please proceed to question 68)
- Complement each other (please proceed to question 66)
- Neutral (please proceed to question 69)

66. If indicated "complement", do the subsidiaries collaborate?

- Yes (please proceed to question 67)
- No (please proceed to question 69)

67. What is the division of activities?

.....
.....

68. If indicated "compete": the most important direct competitors to this establishment are subsidiaries in: please indicate regions and/or countries:

.....

69. If indicated "compete", what is the basis of competition between subsidiaries?

- Performance (productivity/efficiency)
- Product lines
- Functional activities
- Other, such as:

70. How would you value the mutual relationships between Asian subsidiaries within the company?

- very important
- important
- neutral

- unimportant
- very unimportant

71. How would you rate the position of this establishment vis-à-vis...?

- a) Regional head-quarter very strong strong same weak very weak
- b) Other subsidiaries in Asia very strong strong same weak very weak

72. In your view, have there been any changes in this subsidiary's position with respect to other subsidiaries in Asia within the company over the past ten years (or since establishment)?

- Yes, the position of this establishment has become stronger
- Yes, the position of this establishment has become weaker
- No change

73. With respect to change, has the establishment taken initiatives on its own accord regarding its position within the company?

- Yes
- No

74. If indicated "yes", what kind of initiatives?

.....

.....

V. Future prospects

75. Within the next five years, what are your expectations with respect to this establishment?

	Increase	Decline	Same
Product line(s)			
Activities/functions			
Quality (upgrading)			
Position in company			

76. In your opinion, what are the prospects of this establishment for the next five years?

.....

.....

.....