HOW DOES THE RISE OF CHINA AFFECT MALAYSIA'S ELECTRONIC AND ELECTRICAL SECTOR?

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ABSTRACT

After joining the WTO in 2001, China's total exports grew by 19.3% per annum up to 2013 and the country emerged as the world's biggest exporter of manufactured electronics. China's rise has had an impact on developing countries such as Malaysia, a major exporter of electronic and electrical (E&E) goods. Malaysia aims to be a high-income economy by 2020, and upgrading its E&E value chain is critical to this goal. Malaysia is part of the East Asian production network and China imports intermediate inputs from Malaysia's E&E for its final exports while simultaneously expanding in similar product spaces. This means the effect on Malaysia of China's rise is complex.

Contemporary literature divides the impact of China's rise into competitive and complementary effects, and this research aims to further understand the effect of China's rise on Malaysia's E&E trade and investment channels, using a mixed methodology approach. The research analyses the bilateral E&E trade patterns, the extent of trade competition at the destination markets, with the trade structure disaggregated by sophistication and by type of goods[1] analysis. Subsequently it examines China's impact on the semiconductor machinery segment, a backward linkage of the IC industry. Finally, the influence of China's rise on investments aspects of Malaysia's E&E industry is also explored.

[1] Types of goods category such as final goods, parts and accessories or durables.

The research finds that while imports from China compete with imports from Malaysia in the US and Japanese markets (the EU market is different), China's competition in trade is also spurring Malaysia to upgrade its exports' sophistication. China also creates new demand for Malaysia's semiconductor machinery. Finally, while resulting in short-term job losses, China's diversion of E&E investment from Malaysia provide opportunities for Malaysians to start new firms, and for MNCs based in Malaysia to upgrade their production.

Contents

List of Tables

List of Figures

List of Abbreviations

AMD	Advanced Micro Devices
AOI	Advanced Optical Inspection
ASEAN	Association of South East Asian Nations
AXI	Advanced X-ray Inspection
BEC	Broad Economic Category
CAGR	Compounding Annual Growth Rate
CGE	Computable General Equilibrium
CREST	Collaborative Research in Engineering, Science & Technology
CWG	China White Goods Company (firm renamed)
DIA	Direct Investment Abroad
DRAM	Dynamic Random Access Memory
E&E	Electronics and electrical
EDN	Electrical Design News (formerly)
EMS	Electronic Manufacturing Services
EOI	Export Oriented Industries
EPZ	Export processing zone
EU	European Union
EXPY	EXPY index
FDI	Foreign Direct Investment
GPN	Global Production Network
GVC	Global Value Chain
HS	Harmonised Systems Nomenclature
IC	Integrated circuits
ICT	Index of competitive threat
IMF	International Monetary Fund
InvestPenang	Invest-In-Penang Berhad
IP	Intellectual Property
ISIC	International Standard for Industrial Classification
JV	Joint-Venture
LCD	Liquid Crystal Display
LED	Light emitting diode
MATRADE	Malaysia External Trade Development Corporation
MIDA	Malaysian Investment Development Authority
MIMOS	Malaysian Institute of Microelectronics Malaysia
MITI	Ministry of International Trade and Industry
MNC	Multinational corporations
MSC	Multimedia Super Corridor

MSIC	Malaysia’s Standard Industrial Classification
NDA	Non-disclosure agreements
OEM	Original Equipment Manufacturer
OBM	Original brand owners
PC	Personal computer
PCB	Printed circuit board
PRODY	PRODY index
PSDC	Penang Skills Development Corporation
PV	Solar Photovoltaic
PWC	PricewaterhouseCoopers
R&D	Research and Development
RCA	Revealed comparative advantage
RF	Radio-Frequency
RM	Ringgit Malaysia
SEM	Semiconductor Equipment Manufacture
SEMI®	Semiconductor Equipment and Materials International
SEZ	Special Economic Zone
SMIC	Semiconductor Manufacturing International Corporation
SRM	SRM
TalentCorp	Talent Corporation of Malaysia
TCI	Trade complementarity index
TEEAM	The Electrical and Electronics Association of Malaysia
TFT	Thin-film-transistor
TM	Telekom Malaysia
TSMC	Taiwan Semiconductor Manufacturing Company
UBM	UBM Tech Group
UMC	United Microelectronics Corporation
UNCTAD	United Nations Conference on Trade and Development
US	United States
VSS	Voluntary Separation Scheme
WITS	Woldbank Integrated Trade Solutions
WMS	World market share

1.0 Introduction

China's emergence as a global economic powerhouse is seen as an economic miracle of the 21st century. Achieving on average 10.0 percent annual economic growth, China has lifted 500 million of its citizen out of poverty in the last 30 years (The World Bank and Development Research Center of the State Council of the P. R. of China, 2013). China is the current world's number one exporter of electronic and electrical goods, overtaking the US, the EU, and Japan.

For the rest of the world this is a mixed blessing. While consumers at exports market are happy with Chinese cheap clothing and electronics, industries in other countries have been affected to different degrees. In one country, news headlines include a factory shutting down after being out-competed by China or factories moving to China with workers being laid off concern policymakers, commentators, and ordinary citizens, while in another, big corporations are celebrating the fact that the Chinese, richer than their parents, are now the biggest consumers of their high-end cars and other luxury goods.

While developed countries' benefit from high-technology exports to China is less likely to be negatively affected by the rise of China in the medium term, the effect of China on developing countries with mid-technology and middle-incomes such as Malaysia is less clear-cut. China imports intermediate inputs from Malaysia for its final exports, but at the same time competes with Malaysia in labour-intensive assembly industries. This research seeks to better understand the effect of China on Malaysia in a high-technology industry, namely the electronic and electrical industry. Furthermore, Malaysia is keen to avoid the middle-income trap and aims to become a high-income economy, with the upgrading of its industry a crucial development goal (Economic Planning Unit (Malaysia), 2010). Given the rise of China, this represents both a challenge and an opportunity for Malaysia.

This chapter is organised as follows; the next section presents the background to the problem of China's emergence in the global economy, followed by a sectoral view of China's emergence from Malaysia's E&E sector. Then I present the study's problem statement followed by a discussion of current research gaps, which inform the aims, and research questions of this study. The outline of the thesis is presented in the final section.

1.1 The Global Economy and China's Emergence

Globally, most observers concur that China's rise as an economic power is irreversible. China's share of world GDP is estimated to increase from 4.7% in 2005 to 7.6% by 2020 (Winters and Yusuf, 2007, p. 6). The Asian Drivers[2] literature stresses that due to the size of its economy and its combined foreign exchange reserve of more than US$700 billion, China (and to a lesser extent India) will have an increasing impact on the developing world and developing world's strategy for development moving forward (Kaplinsky and Messner, 2008). The Asian Drivers literature discusses wide-ranging impacts including on production and trade flows, financial flows, environmental spillovers and global governance. This study focuses on production and trade flows.

[2] The Asian Drivers include China and India, but I confine my interest to China in this research.

The rise of China within the globalization heralded a new era with China's entry into the WTO in 2001. Since then its exports have been expanding at a rate of 19.3% per annum up to 2013, signalling its greater integration into the global production network. Likewise, inflows of foreign direct investment (FDI) into China rose 17-fold from US$3.5 billion in 1990 to US$60.6 billion in 2004, while ASEAN's share of FDI in Asia fell from 30.2% in 1992 to 4.2% in 2004 (Salike, 2010). Feeling the heat from China, the Prime Minister of Malaysia at the time, Mahathir Mohamad, remarked: 'Everyone is feeling the pinch because the amount of FDI has shrunk and then, a lot of that is going to China' (New Straits Times, 21 September 2002 in McKibbin and Woo (2003, p.14.).

The rapid rise of China raises questions about its impact on the developing world (IDS, 2006). While there is fear that China's growth will displace exports from developing countries, there is also a positive side: the creation of new investment by China and higher demand for imports of inputs into China's final exports. Furthermore, as China's population grows wealthier the demand for imported final goods also increases. At the macroeconomic level, while Malaysia is benefitting from the rising prices of commodity exports to China such as crude oil and agricultural products such as palm oil, the deeper question raised is the long-term competitiveness of the Malaysian manufacturing industry. These two sides of China's impact on its neighbours, widely termed as competitive or complementary effects, are central to the discussion in this study.

Malaysia aims to advance from a middle-income to a high-income economy by 2020, with a growth target of 6.0% per year from 2011-2015. A key strategy towards this goal is to upgrade its industry to high-value-added activities (EPU, 2010). As the E&E sector contributes around 40% of the total manufactured exports of Malaysia and represents 26.1% of total manufacturing output (EPU, 2010, p. 131), upgrading the E&E value chain is crucial to reaching this goal. Apart from the size of its contribution, the electronics sector is described by Hirschman 'as a propulsive sector' in the economy that reinvents itself and is essential for the diffusion of technology (Sturgeon and Kawakami, 2010).[3]

However, structural issues within Malaysian industry and the challenges posed by China do not help with the upgrading of the value chain. Firstly, the manufacturing industry's contribution to Malaysian GDP has declined from its peak of 34.4% in 2000 to 24.3% in 2012. Secondly, Malaysia's FDI-based export model mainly concentrates on assembly and testing (Ernst, 2004), and weak linkages between its export-oriented industry and domestic economy hamper the upgrading to higher-value-added activity (Alavi, 2002). This is alarming, as the manufacturing industry is crucial to promoting linkages between different sectors within the economy and upgrading the value chain (Naudé and Szirmai, 2012).

1.2 China's Emergence and Malaysia's Electronic and Electrical Industry

The case for research to evaluate China's impact on a neighbouring developing country has never been stronger, as in 2009 it emerged as Malaysia's top trading partner, overtaking traditional trade partners such as the US and Japan. Malaysia's exports and imports of electronic and electrical products rose from US$0.03 billion and US$0.07 billion in 1992 to US$ 12.9 billion and US$ 15.1 billion in 2013 respectively.[4]

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[3] By 'propulsive sector' Hirschman meant a rapidly changing sector with a positive technology spillover in the economy.
[4] The electronics and electrical sector is defined in this study as the sum of 338 products at the 6 digit-level under HS 1998/92 Nomenclature.

While the increasing volume of trade with China should be celebrated, some, such as Fong Chan Onn, the then Malaysian Human Resources Minister, cautioned: 'China is a threat. Malaysia must learn to cope with this emerging trend and rectify weaknesses to remain competitive in critical industries such as electronics' (Malaysiakini.com, 9 April 2002). Understandably, this sentiment is due to the loss of manufacturing jobs associated with factories shifting from Malaysia to China early in the 2000s, and as the minister in charge of manpower he was rightfully concerned.

Secondly, Malaysia is also concerned that its household electrical industry is increasingly being flooded with imports of radios, televisions and small electrical items from China, which will impact on the local manufacture of electrical items. *Durables goods*, which consist mostly of household electrical products under Broad Economic Categories (BEC) (see Chapter 5) show Malaysia's widening deficit in the balance of its bilateral trade with China year after year, from US$1.9 million in 1992 to US$263.2 million in 2013.

On the other hand, Malaysia exports more semiconductors to China as a result of the rise in the processing trade in which components are sourced from overseas to assemble into final goods in China. Malaysian IC exports to China rose from US$611,570 in 1992 to US$8.4 billion in 2013. While Malaysia benefits from this, its IC exports to third-destination markets such as the US, European Union and Japan compete with semiconductors produced in China. It is also speculated that China will upgrade its export sophistication and that medium-technology countries such as Malaysia will be increasingly vulnerable to China's export threat (Lall and Albaladejo, 2004).

1.3 Problem Statement

China's rapid expansion in E&E production is benefiting Malaysia, which is exporting more intermediate parts and components to China to feed into its production networks, but at the same time Malaysia faces competition from China in E&E exports in third markets and import penetration of domestic markets. The positive side of China's rise is characterized in terms of complementary effects, and the negative side as competitive impacts. Apart from the trade aspect of China's impact, Malaysia is also affected through the investment channel. The issue is currently framed more as a case of the diversion of FDI from Malaysia to China in the current literature, and needs to be weighed against China's FDI into Malaysia's E&E industry. As investment in Malaysia's E&E industry is generally linked to trade, it is important to see whether China compensates for displacing finished electrical goods exports from Malaysia, which predominantly consists of exports by foreign multinational corporations (MNCs) such as Japanese MNC plants based in Malaysia.

1.4 Research Gaps

The globalisation literature on China's impact on developing countries discussed above reveals that China's impact on Malaysian trade and investments is not clear-cut and remains a rich area for further research. The following facts support further research to understand the impact of China's rise on Malaysia's E&E sector:

- World Bank and IMF impact studies based on model simulations are dependent on highly aggregated data and do not take into account the heterogeneity of the traded goods (see Chapter 2).
- The effect of China's export competition on Malaysia's industries is not uniform across different players in the E&E sector. China's

impacts on a multinational corporation and a subcontract supplier are different, and their response could be different as well.

- The behaviour of China's FDI outflows and its motivation and impact on a middle-income country such as Malaysia are less well documented at the firm level. Moreover, given the trade-investment nexus in the Malaysian electronics industry, the discussion linking both trade and the investment sector with China needs to keep up with recent trends.
- Current literature, especially that with a Malaysian origin, casts China in the role of a competitor for trade. This needs to be weighed against China's recent demand for semiconductor machinery equipment from Malaysia's semiconductor machinery sector.
- While Malaysian-based literature on the electronic sector such as Rasiah et al. (2010) and Rasiah and Shan (2012) is useful to understand the development path of each country in East Asia, it has not specifically focused on the impact on these developing countries of China's rise.

1.5 Research Aims and Objectives

The broader research aims here are to examine the impact of the re-emergence of China on Malaysia's E&E sector and to look at Malaysia's E&E firms and government's responses to China's rise.

The main objective of the research is to investigate the impact of China's rise on Malaysia's E&E sector through the trade and investment channels. The E&E sector is the focus of the research followed by global value chain (GVC)/ global production network (GPN) studies of the integrated circuits

(IC)[5] industry and the small household appliance industry based in Malaysia.

Specifically, this study intends to find out:

- whether China's rise complements or competes with Malaysia's E&E sector
- whether disaggregation by level of sophistication of Malaysian E&E imports at destination markets can reveal whether Malaysia's E&E industry has upgraded in response to China's rise.
- The complementary aspects of the East Asian regional production network including backward linkages to the E&E industry and especially in the semiconductor industry between Malaysia and China.

1.6 Research Question

Based on the research aims above, the main research question is:

What is the effect of China's rise on Malaysia's electronics and electrical industry?

The above main research question is further divided as follows:

A. Is the rise of China complementary or competitive with Malaysia's E&E?

- Trade Channel
    1. Does the bilateral trade structure reflect a complementary type of specialisation within the E&E value chain between Malaysia and China?
    2. To what extent do China and Malaysia's E&E exports compete in their destination markets?

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[5] Integrated circuits are also referred to as semiconductors. Semiconductor materials are fabricated into integrated circuits and IC is the most important sector within semiconductor industry.

3. Based on the disaggregation of imports from Malaysia at destination markets by level of sophistication, is Malaysia's export structure consistent with the upgrading of its E&E industry?

- Investment Channel
  4. At the bilateral level, does the investment flow reflect complementarity in sub-sector investment, and what are the drivers of Chinese FDI in Malaysia? Which sub-sector are Malaysian E&E firms entering in China?
  5. Which sub-sector within Malaysian E&E is affected by the diversion of investment to China, and what is the effect on the E&E sector?

B. How is Malaysia responding to China's rise at the government and firm levels?

6. How are Malaysia's firms responding to the rise in China's E&E trade and investment?
7. How are Malaysian government agencies responding to China's rise in for trade and investment?

C. How China affects Malaysia's efforts to upgrade its E&E value chain?

1.7 Thesis Outline

The thesis consists of nine chapters. The first chapter introduces the research problem and provides an overview of the thesis. Chapter 2 elaborates on the theoretical framework underlying the methodology (Chapter 3) used to analyse the data. Chapter 4 sets the scene by discussing the evolution of the E&E industry in both Malaysia and China.

The thesis then goes on to the results, with Chapter 5 presenting some preliminary data on bilateral trade at total trade and E&E level. Chapter 6 takes the trade analysis further, analysing the rise and fall of imports share from Malaysia and China's E&E for trade in destination markets. Chapter 7 expands the analysis of China's impact on Malaysia in a backward linkage industry, namely the semiconductor equipment machinery industry. Chapter 8 presents the analysis of China's impact on Malaysia in investment channel and, Chapter 9 concludes the findings of this thesis and offers suggestions for future research.

2.0 Literature Review and Theoretical Framework

This chapter first reviews studies related to China's impact on its neighbours and then presents the theoretical framework for the study. The literature review reinforces the problem statement in Chapter 1: studies of China's effect on its neighbours are not clear-cut on whether China's re-emergence is a complementary or competitive force. The literature review also elaborates on the research gaps mentioned in Chapter 1.

The chapter is organised in the following order: a discussion of globalisation literature such as that on the impact of the Asian Drivers on the global economy is followed by econometric-based studies, competitiveness literature, spin-off theory, and the global value chain (GVC) and global production network (GPN) frameworks. Elements of these frameworks are then incorporated into the theoretical framework to discuss the impact of China on Malaysia's E&E industry.

2.1.1 The Globalisation and Asian Drivers Literature

At a global level, the Asian Drivers literature predicts that China will have an increasing impact on global trade and investment flows. This is because of the sheer size of the Chinese economy (Chinese exports grew from US$50 billion to US$798 billion from 1985-2005), the high level of state ownership of enterprises and the active intervention of the state in the marketplace and importantly, the combination of low price and high innovation potential presents a great challenge to other developing-country exports (Kaplinsky and Messner, 2008). The Asian Drivers literature considers other aspects of China's impact such as the environmental aspects, financial markets and global governance of multilateral institutions, but this study focuses on its impacts on trade and investment.

Kaplinsky and Messner (2008) note that growth in the trade of manufactured goods was coming from the East & Southeast Asia block in the 1970s and 1980s, predominantly from Japan and the Asian Tigers. However, in the last decade of the 20th century China (together with India) began to drive the growth of the East Asia region. Malaysia and China are part of the production network in this region; this reinforces the problem statement (see Chapter 1), with China's rise having both complementary and competitive effects on Malaysia's economy.

Kaplinsky and Morris (2009) look at the trade impact of the Asian Drivers and the prospects for Sub-Saharan Africa (SSA)'s export-oriented textile industry following the removal of preferential import quotas into the US and EU market on 31 December 2004 under the Multifibre Arrangement⁄Agreement on Textiles and Clothing, which previously granted SSA countries preferential access to export markets. The results of the withdrawal of preferential treatment are that SSA exports are being squeezed out by Chinese and Vietnamese textile exports. The textile industry, as a lower-technology industry, is regarded as a stepping stone into industrialization for many countries developing their economy. In contrast, this research looks into the impact of China on a developing country's high-technology and exports-oriented E&E industry.

Altenburg et al. (2006) look at the effect of China on the developing world as it climbs the technology ladder. China can provide more appropriate technology solutions to the developing world compared to the developed world, given its lower costs. However, the 'flying geese' theory that predicts China will leave the lower-cost production segment to other developing countries, as Japan did in Asia, is dismissed as China has a huge reserves of labour ready to replace lower production segment vacated domestically by industries that are climbing the technology ladder. Altenburg et al. (2006) predict that China's rise in technology will result in higher barriers to entry for newcomers to technology via competition in exports.

Apart from the trade effect, Kaplinsky and Messner (2008) note the impact of the Asian Drivers on developing countries through the investment channel. Although China and Hong Kong attract about 40% of the total world inward FDI destined for the developing world (UNCTAD, 2005 in Kaplinsky and Messner, 2008), China itself is increasingly becoming a source of outward FDI in its search for resources and markets (Kaplinsky and Messner, 2008).

The Asian Drivers literature provides a systematic framework with which I analyse China's direct and indirect, complementary and competitive impacts on its neighbours. This framework is proposed to launch an investigation into the impact of China as an Asian Driver; 'What we do not know is how these processes of change in trade flows and terms of trade are affecting other developing countries' (IDS, 2006).

Table 2.1 Direct and Indirect Effects of Asian Drivers Framework

Channel	Impact	Direct	Indirect
Trade	Complementary	China's final exports contain parts from imported from Malaysia	China's demand for commodities increases the price of oil
	Competitive	Imports from China displace local producers	Chinese exports compete in third markets and displaced Malaysian exports
FDI	Complementary	Inflows of FDI from China	US/EU/Japan invest in Malaysia with a view to supplying China
	Competitive	Crowding out of local producers	Diversion/relocation of US/European/Japanese FDI to China

Source: Adapted from Kaplinsky and Messner (2008)

Table 2.1 summarizes the Asian Drivers theoretical framework that groups types of effect, which guides this research on China's direct and indirect impacts on trade with and investment in the Malaysian E&E sector. The direct effects are caused by bilateral trade and investment and the indirect effects come about due to non-bilateral relationships. The impacts are further categorised into two types of effects: competitive and complementary. For an export-oriented industry such as E&E, indirect impacts such as export competition for third markets must be weighed against direct impacts such as Malaysia's export of intermediate product to China.

2.1.2 Simulation Models and Econometric studies

Another group of the literature studying the macroeconomic impact of China on different geographical regions are the simulation models and gravity models studies. Simulation models are popular with international multilateral agencies for predicting China's impact on different regions within the global economy. A number of World Bank studies are based on results generated from the Global Trade Analysis Project (GTAP), a variant of computable general equilibrium (CGE) modelling. Briefly, model simulations are based on systems of equations and mimic the behaviour of households, governments, the labour market and businesses, with market-clearing assumptions built into the model. CGE modelling simulates the different impacts on overall GDP growth on different areas and sectors of the global economy. Normally they compare a baseline scenario with another scenario to which shocks or intervention are applied to the model. These CGE models are generally used for predictive studies.

CGE-based studies such as that of Winters and Yusuf (2007) believe that China's rise benefits East and South-east Asia due to the existence of the production network in the region, and that the effect on Latin America is neutral because Latin America's export basket is different from China's.[6] International multilateral agencies take a similar view: that China's effect on other Asian exporters is positive at a regional level. Ianchovichina et al. (2003, p.78) of the World Bank sums up the impact of China's WTO accession:

> Because trade intensity with China is high for all emerging East Asian economies, they stand to benefit from this dynamic growth. Growth in the region's exports will also be fuelled by the increased demand from China's major trading partners that benefit directly from China's accession.

Similarly, (Yang, 2003) of the IMF finds no long-term negative effects of China's entry into the WTO on developing countries.

Multilateral agencies' optimistic view of the effects of China's rise is dismissed by Eichengreen and Tong (2007) as '…blanket statements concerning China's impact are not particularly supportable. The country's emergence is a mixed blessing requiring a nuanced analysis'.[7] Furthermore, Yang (2003) model simulations unrealistically assume adjustment costs to China's rise for the developing country to be zero when in reality shifting labour across different sectors of industry, as a result of loss of certain exports sectors by developing countries to China will not be costless.

The above criticism of CGE models brings us to the next group of studies, econometric-based gravity model studies. A gravity model is basically a regression model, and these are generally divided into trade and investment models. A gravity model is premised on the idea that the size of a country's trade is related to its trade partners based on distance,

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[6] High-technology sectors in OECD countries are not easily affected. However, South Asia is already being negatively affected, with its textile exports facing competition in third markets (Winters and Yusuf, 2007).

[7] For a full critical view of China's impact, refer to Kaplinsky (2005).

whether they share borders, size of trading-partners' economies, and income level of the trade partners. Although variations exist in different authors' gravity models, most test the relationship between neighbours' exports and Chinese exports (as the independent variable). Investment gravity models test the relationship between China's neighbours' and China's inward FDI.

Interestingly, Winters and Yusuf (2007) believe that China's rise poses the biggest challenge to Asian and Latin American middle-income countries compared to low or high income countries because China is likely to expand into the same product space. As part of the MNC production network, these countries will be affected if China moves into component manufacturing (Winters and Yusuf, 2007). However, Winters and Yusuf (2007, p.40) admit that 'the situation is less clear' for electronic components, a major East and Southeast Asian export, because China is expanding its exports while simultaneously the centre of production in East Asia, increasing the interdependence of trade in the area.

The conflicting findings of gravity model studies make it difficult to determine whether China is a competitive threat or a complementary force to its neighbours' exports. Eichengreen et al. (2007) and Greenaway et al. (2008) trade gravity models find that China's exports have an overall displacement effect on other Asian exporters. Conversely, Athukorala (2009) finds that China plays a complementary role in the region by separating exports into parts and components and final goods. Devadason (2010) also concludes that China's exports are not displacing those of other East Asian exporters. [8] Kong and Kneller (2015, p. 4.) review previous

[8] Devadason's (2010) study focuses on ASEAN (Malaysia, Singapore, Thailand, Indonesia, the Philippines, Cambodia, Laos, Myanmar, Vietnam), while Athukorala (2009) includes Japan, Hong Kong, Korea, Taiwan, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam.

studies and report that the gravity models of Eichengreen et al. (2007), Greenaway et al. (2008) and Athukorala (2009) show sensitivity to both the time period and the methodology used.

Investigating China's effect on aspects of its neighbours' FDI inflows, an early study by McKibbin and Woo (2003) simulates the impact of China's ascension to the WTO on its neighbours using a modified general equilibrium model, and predicts that FDI will be diverted from ASEAN-4, which includes Malaysia, resulting in lower economic growth there. Hence the ASEAN-4 countries must improve their technology diffusion capability in their industry to avoid these negative effects from China. Weiss (2006) argues that McKibbin and Woo (2003) assume the diversion of FDI in their model simulation; this is contestable as the amount of FDI into China also corresponds with the size of the economy and population.

Investment-based gravity model studies examining whether China has diverted FDI away from its neighbours have also produced inconclusive findings. Chantasasawat et al. (2004) and Eichengreen and Tong (2007) find that China's FDI inflows are complementary to the total FDI inflows of its East Asian neighbours.[9] Narrowing it down to Japanese outward FDI to the East and Southeast Asia region, Eichengreen and Tong (2007) find that Japanese FDI to China correlates positively to Japanese FDI inflows of neighbouring Asian countries. Conversely, Salike (2010) finds that Japanese FDI outflow to the region has been diverted away from its Asian neighbours.[10] When FDI inflows are disaggregated by industry, Eichengreen and Tong (2007) find that Japanese FDI into China is complementary to the regional FDI for the electrical industry. In contrast,

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[9] Chantasasawat et.al (2004) refer to the Asian region as the East and South Asia region, while Eichengreen and Tong (2007) define the Asian region as including East, Southeast, and South Asian countries.
[10] The Asian region comprises Hong Kong, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand and Vietnam.

Salike (2010) finds that China's total inward FDI from Japan competes with that of its neighbours in the E&E industry. Details of the gravity models of regional trade and investment studies are shown in Table 2.2 below.

Table 2.2 Main findings of various gravity models

Authors	Model	Results
Trade		
Eichengreen et al. (2007)	1990-2003 OLS and instrumental variable estimator (IV) comparison	Competitive
Greenaway et al. (2008)	1990-2003 (IV)	Competitive
Athukorala (2009)	1992-2005 IV based on the generalised method of momentum (GMM-IV)	Complementary
Devadason (2010)	1995-2006 OLS	Complementary
Kong and Kneller (2015)	1994-2008 two-stage IV model	Complementary to human capital at destination market
Investment		
Chantasasawat et al. (2004)	1985-2001, two-stage simultaneous equations	Complementary
Eichengreen and Tong (2007)	1988-2000, IV and OLS comparison	Complementary
Salike (2010)	1990-2004, GMM	Chinese inward FDI competes with its neighbours for Japanese FDI

IV= instrumental variables, GMM=Generalised Method of Moments, OLS=Ordinary Least Squares
Source: Adapted from Paniagua (2014)

It is important to note that gravity model studies focus on China's regional effects at an aggregated level. According to Weiss (2006) in Humphrey and Schmitz (2007, p. 29.) 'they assess whether total FDI to the region is influenced positively or negatively by FDI to China, rather than looking at individual country effects.' Although some gravity model studies still divide effect at country level the findings are nevertheless for the electronics industry on the whole, and this hides the effect at a disaggregated level, where China has different effects depending on the technological level of the export.

The data input for investment gravity model studies is more prone to measurement error, as investment data is less standardised than trade data because different countries have different definitions of investment. For example, some countries might recognize reinvestment as investment but others may not and therefore, reinvestment is not captured by the investment statistics. In view of this Weiss (2006) in Humphrey and Schmitz (2007, p. 29) concludes that 'FDI diversion, whilst it may exist, has not been found conclusively in recent studies.'

Other studies considered here (Mercereau, 2005, Zhou and Lall, 2005); (Wang et al., 2007) do not specifically mention the gravity model term, but the regression model works on the same principles. These studies find that China FDI inflow effects on its neighbours FDI inflows are largely neutral or even complementary. Mercereau (2005) model design regards only a portion of total inward FDI into China as diverted rather than treating the whole of its inward FDI as a diversion. This point is reinforced by Zhou and Lall (2005), who dismiss their own conclusion citing the absence of credible ways of discerning inward FDI into substitutable investment, typically in export-oriented sectors, compared to resource-seeking or market-seeking investment in China.[11] Finally Wang et al. (2007) find that China's effect on investment flow could be complementary for its neighbours at the aggregate level but at disaggregated levels their model finds that Chinese inward FDI investment competes with that of Malaysia, Taiwan, and South Korea while it complements that of India and the Philippines. Again, these studies of investment are inconclusive about China's effect on its neighbours; however the point to note is that there is a need to distinguish between different types of investment data for the models to be credible.

[11] Zhou and Lall (2005) mentioned that some industry is more 'substitutable' than others by location. For example, heavy chemical industries are less substitutable compared with electronics, because the industrial process itself.

Reverting to CGE model studies, Ianchovichina et al. (2010) simulate China's impact on Malaysian trade from 2005-2020 at the macroeconomic level. The results show that Malaysia benefits from rising prices in commodity exports but its manufacturing sector will suffer disproportionately with a 7.0% decline. Ianchovichina et al. (2010) propose future work on China's impact at a sectoral level because their findings are based on highly-aggregated data and therefore cannot account for heterogeneity in exported goods. The present study aims to address this limitation.

From the discussion above, gravity models are known to be sensitive to data periods and model specification and are therefore inconclusive about China's effect on its neighbours. Likewise, the CGE model-based study is more of a predictive tool and is sometimes based on the unrealistic assumption that adjustments in the regional economy will be costless with China's rise. Winters and Yusuf (2007, p.22) comment 'Modelling exercises are parables, not predictions. One should not take the precise numbers literally, and within each of our aggregates (say, electronics) there will be a wide range of effects across different products', precisely pointing out why CGE-based studies are not suitable for use in my study. This sectoral study requires more disaggregated detail of the impact on Malaysia's E&E industry by sub-sector. I now turn to the next area of literature, the competitiveness studies.

2.1.3 Competitiveness studies

The term 'competitiveness studies' is used here to refer to studies that measure market share to draw conclusions about the competitiveness of a nation in the export sector. There are variations in the formulas across different authors but the basic building blocks are export market shares.[12] Some competitiveness study findings are contrasted with the CGE and gravity models discussed in the earlier section. The main strength of the competitiveness-based studies is that exports can be analysed at a disaggregated level, which is suitable for this sectoral study.

In contrast to World Bank and IMF studies based on CGE models, models such as those of Yang (2003) and Weiss and Gao (2003), using a derivative market share methods called constant market share, find that ASEAN is losing market share in the US and Japan export market to China despite rising ASEAN-5 export figures[13] from 1995-2000 by product category.[14] In the Latin America region and contrary to Winters and Yusuf (2007), Jenkins and De Freitas Barbosa (2012) find that Chinese exports not only compete with traditional Brazilian industries including footwear and garments, but with increased import penetration in the electronics industry. This form of disaggregated analysis by sub-sector shows the strength of competitiveness analysis.

Another strength of competitive analysis is the ability to disaggregate the export structure into different levels of sophistication. Lall and Albaladejo (2004), pioneers in this, discern the effects of China's growth the exports of other Asian exporters based on high, medium and low technology segments. Based on rising or falling world export shares, Lall and Albaladejo (2004) find that China's toy exports compete with those of lower-technology exporters such as Indonesia. For high technology electronics industry exporters such as Japan the effect is complementary,

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[12] See Appendix 2.1for more detail.

[13] Indonesia, Philippines, Malaysia, Thailand and Singapore.

[14] Weiss and Gao (2003) find a consistent loss of ASEAN's E&E market share in US and Japan market. The derivative market share includes regressing the Competitiveness of ASEAN countries with in-built independent variables that compares China's market share in export market with ASEAN's market share. This link between the idea of Competitiveness and market share is established.

because Japan exports intermediate components that are used in China's final exports. As China further upgrades its technology, Malaysia is singled out by Lall and Albaladejo (2004) as vulnerable to China's export threat in the electronics sector.

Disagreeing with Lall and Albaladejo (2004), Shafaeddin (2004) argues China's exports do not threaten Malaysia's high-technology exports in the short and medium term, as China requires time to upgrade. Similar to Lall and Albaladejo (2004) disaggregation of the export structure into high, medium and low technology but presented instead in terms of specialisation, Coxhead and Jayasuriya (2010) provide another reason for why countries such as Malaysia and Thailand, which have slightly higher-skilled labour, can cope better than Indonesia with the rise of China. Malaysia and Thailand will be able to offset their loss of low-skill export segments with higher-skill exports and benefit from China's rise, compared to Indonesia.

Nevertheless, Shafaeddin (2004) admits that in the long term the competitive threat of China's exports to Malaysia's high-technology segment may increase when China upgrades its technology. To check whether China's complementary role as the regional production centre is indeed diminishing, Cui and Syed (2007) analyse its export and import structure and find that the technology gap between these segments is narrowing over time, implying that China will import fewer intermediate parts as it develops greater technological capability. Conversely, Park and Shin (2011) argue that China's diminishing share of intermediate imports counter-intuitively shows that it is increasingly a complementary force. As China's overall imports from East Asia increase any decrease in the import share of components means that more finished goods are imported into China. This indicates a switch from being a processing trade centre to the role of final consumer.

Going further on the issue of trade competition as China upgrades the technology of its exports, Rodrik (2006) and Schott (2008) measure China's level of export sophistication against that of other countries to examine export competition based on level of sophistication. They conclude that China's exports basket is more similar to high income OECD countries than to those of developing countries, given its level of development as indicated by its per capita income of a developing country. This increases the prospects of China's competition in high-technology segments such as the E&E industry. However, Xu (2010) casts doubt on Rodrik (2006) and Schott (2008) conclusion that China's export composition is 'special' because the use of national per capita income (a major component in generating PRODY) in their metrics does not account for disparities between provinces in China and the lower quality of Chinese exports with the same export product code. For example, although a Dyson vacuum cleaner has the same export code and PRODY index as a generic brand, Dyson is priced in a higher end segment of the vacuum cleaner market, its quality is much higher and it has more features.

Competitiveness studies on Chinese exports do not however separate out the use of high-technology intermediate imports embedded within Chinese exports due to the current method of measuring trade at the final output level. This points to the limitation of competitiveness studies and to one of the strengths of GVC and GPN studies, which are gaining acceptance in studies of trade and production. Further details are provided in section 2.1.4 on GVC and section 2.1.5 on GPN.

A final note: although competitiveness studies are unable to claim direct causality (as econometrics models would) on China's effects on its neighbours, they do show that China's rise affects different countries differently based on their specialisation in international trade. To understand China's medium-term threat to its neighbours some studies analyse the structure of its exports and imports while others measure the product sophistication of its exports over time. Although Lall and Albaladejo (2004) discern China's impact on its neighbours based on its high, medium and low technology exports, classing the entire E&E industry as high-technology can be a weakness. This study divides the export structure by sophistication, using the PRODY index (Hausmann et al., 2007). Table 2.3 below, presents a summary of the competitiveness studies discussed here.

Table 2.3 Summary of Competitiveness Studies

Authors	Method	Findings
Trade		
Lall and Albaladejo (2004)	World market share	China is a threat to its neighbours based on its exports segment. Discernible by level of technology. Among the developing countries, Malaysia is most vulnerable to Chinese export competition.
Shafaeddin (2004)	Revealed comparative advantage Rank correlation of RCA	China is unlikely to threaten mid-tech countries such as Malaysia in the immediate term, but may become a threat if China upgrades its technology and moves into components manufacturing. This would take some time.
Roland-Holst and Weiss (2004)	Measures competitiveness of China exports effect on ASEAN imports into the US and Japan market. Competitiveness is decomposed into changes in market share based on changes in Chinese import share at destination market, and relative to China's world exports.	China is competing with ASEAN in ASEAN's most specialized areas.
Rodrik (2006)	PRODY and EXPY index	China's export basket closely resembles the sophistication of the OECD's despite China being a developing country.
Schott (2008)	Import penetration, exports similarities index, regression of within product sophistication, log of unit value ratios of China over OECD unit values	China has an export product mix that increasingly overlaps those of OECD countries and competes for the US market as a destination market.

Authors	Method	Findings
Xu (2010)	Regression with adjusted EXPY index and adjusted per capita GDP of China.	Accounting for income disparities between provinces in China and the lower quality of Chinese products compared to equivalent products manufactured elsewhere (same PRODY index), the sophistication of Chinese exports is close to that of developing countries.
Investment		
Roland-Holst and Weiss (2005)	Simultaneous equations – China inward FDI as a predictive variable of ASEAN country inward FDI, and vice versa in the second equation.	China inward FDI is complementary to FDI flow into the ASEAN region due to production network trade.
Ravenhill (2006)	Descriptive data of FDI stocks in ASEAN and China and some export figures	China's diversion of investment away from its neighbours is overstated in the literature.

Note: Roland-Holst and Weiss (2004), Roland-Holst and Weiss (2005) use market share methods together with some econometrics, but the main idea is still about the competitiveness of industries. Detailed formulae are available in Appendix 2.1.

Source: Own Elaboration

Malaysia-based literature discusses the China effect in trade, but indirectly. Abidin and Loke (2008) find that the revealed comparative advantage (RCA) index for Malaysia's E&E export has declined since the late 1990s and attribute this to the challenged posed by China's rise. They recommend that Malaysia should export more resource-based products whose RCA is improving over time, resonating with the 'primarisation' theme, which expresses a common fear in Latin American economies following China's rise (Jenkins and De Freitas Barbosa, 2012).[15]

The Malaysian studies also discuss internal structural issues in Malaysian industry. Rasiah (2010) argues that Malaysian industrial structures have not

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[15] Primarisation' of industry means that a nation becomes more reliant on its natural resource-based industry, rolling back from high technology and sophisticated industry such as manufacturing.

switched to higher-value-added activities.[16] Rasiah (2003) also finds that foreign firms operating in Malaysia use far better technology than local firms. Similarly, Alavi (2002) observes that Malaysia's industrial linkages between export-oriented industries (EOI) and import substitution industries (ISI) are weak, supporting the view that Malaysia's trade is vulnerable to export competition from China. Moreover, the Malaysia-based literature links the decline in export shares and the diversion of inward FDI by multinationals away from Malaysia to the competition from China (Siew-Yean, 2001) (Yusof, 2003).

Kam (2013) contributes to the competitiveness literature by linking total factor productivity with the international production network. Using trade and productivity data from 2000-2008, Kam's findings point to the productivity gains that Malaysia is experiencing by hosting the international production network, but note that technology spillover only occurs with MNCs with certain characteristics. This finding confirms that some form of upgrading is finally occurring due to the presence of the international production network in Malaysia. Kam's econometric model was mainly tested on similar industries grouped by Malaysia's Standard Industrial Classification (MSIC) code. Qualitative interviews investigating links between the E&E industry and its backward linkage industry (see Chapter 7) deepen the analysis of upgrading.

As the trade and investment nexus is prevalent in the East and Southeast Asian region, I now explore the discourse on China's effect on its neighbours via the investment channel. The regional investment trend

[16] While some of Rasiah and Kam's studies are not wholly based on export share but on output or productivity, the basic idea is still comparing industrial competitiveness in the same industry in different countries.

profoundly affects Malaysia's trade performance in electronics.[17] PY Lai, then President of Motorola (China) Electronics, underscored Malaysia's concerns about China's diversion of FDI: 'In 2000, 61 percent of foreign investment in Asia went to China while only 18 percent went to Southeast Asia. The situation was the reverse in the early 1990s' (Malaysiakini.com, 9 April 2002).[18]

However, Ravenhill (2006) argues that China's threat to ASEAN based on its share of the flow of investment is overstated due to failure to distinguish between new investment creation and China's FDI diversion effect.[19] This means that when China is growing, capital accumulation occurs within the economy and FDI increases anyway to profit from the booming population and high economic growth in China. The inflow of FDI into China is further overstated due to 'round-tripping' investment through Hong Kong by China's domestic investors vying for private property protection and access to the generous tax concessions accorded to foreign investors (Xiao, 2004). Ravenhill (2006) argues for a more nuanced analysis of the market share of FDI into China compared to ASEAN, acknowledging that factories are indeed moving out of Penang in Malaysia to China, as discussed in Chapter 8.

The competitiveness-based studies of the China effect on both trade and investment have the strength of being able to disaggregate exports into product levels for an industrial study, which is suitable for detail analysis of a sectoral level study of E&E industry. They also allow for more nuanced

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[17] There is Granger bi-directional causality between inward FDI and the top five Malaysian electronics products, albeit with a short-term effect, meaning that trade and investment are reinforcing each other (Wong and Tang, 2007).
[18] Anecdotally, Malaysian ethnic Chinese were tapped by North American MNCs when they first ventured into China, especially in the 1990s and 2000s decade.
[19] Ravenhill (2006) rejects the zero-sum assumption in the investment case, but the literature is located within the competitiveness literature due to its use of market share.

analysis of the investment channel rather than drawing conclusions from highly aggregated data such as that used in CGE and gravity model studies.

2.1.4 Global Value Chains

GVC studies are qualitative studies describing the chain of production of a product or a group of products and the power relationships between the firms participating in the chain. The origin of the global value chain literature is attributed largely to Gereffi (1994), who coined the term 'global commodity chain'. It transcends traditional economic analysis based on national statistical frameworks. Sturgeon (2001) critiques studies based on national trade statistics as '[unable to avoid rendering] invisible the detailed contours of the world economy' as international production arrangements increasingly fragmented across geographical region. This underlines a key weakness that the GVC framework aims to overcome. The 'fragmentation of the stages of production' refers to the breaking up and segmentation of the various stages of production of a single or related goods in different locations. Predominantly a qualitative study, the GVC is defined as 'input output analysis … where a chain maps the vertical sequence of events leading to the delivery, consumption and maintenance of goods and services' (Sturgeon, 2001, p.10).

More importantly, the GVC points to the weakness of double counting in international trade statistics, which can misinform the debate at policy level. As an illustration, double counting occurs when a component exported from Malaysia to China is booked twice in trade statistics, first when a component is exported from Malaysia and then as part of China's final product exports. This results in the paradox of China being the top global E&E manufacturer according to trade statistics while the actual value added that it captures from export products may be miniscule. As a case in point, only approximately US$25 or 8.5% out of the US$299 wholesale price of an Apple 30 gigabyte iPod player is captured by its assembly in China (Dedrick et al., 2010). According to the Director General of WTO, this dichotomy impacts on trade policy and debates (OECD-WTO, 2012).[20]

GVC demonstrates the importance of the stage of production in which a firm is involved, and this demonstrates the value of a qualitative study. Although Kaplinsky (2010) case study on Thai cassava exports is unrelated to electronics, it shows that China's impact on world trade is not straightforward. China's increased demand for imports of Thai cassava pushes up the trade value, but because the demand is for the primary stages of production this has resulted in the downgrading of the Thai cassava value chain. This study demonstrates China's wider primarisation effect and suggests that studies of its impact should go beyond trade data.

Another important contribution of the GVC literature has been the discussion on upgrading. Firms that participate in a GVC can upgrade as they acquire knowledge by producing and interacting with other firms within the value chain. Related to upgrading, GVC provide a clear typology of various forms of upgrading at firm level within a value chain by Humphrey and Schmitz (2002) in Table 2.4 below.

Table 2.4 Types of Upgrading

Types of upgrading	Description
Process upgrading	Transforming inputs into output more efficiently by reorganizing the production system
Product upgrading	Moving into more sophisticated product lines
Functional upgrading	Acquiring new functions (or abandoning existing functions) to increase the overall skill content of activities.
Inter-sectoral upgrading	Firms of clusters move into new productive activities.

Source: Humphrey and Schmitz (2002)

[20] One of the biggest debates includes the US huge trade deficits with China.

Cattaneo et al. (2013) provide updates on the GVC literature, especially in the area of quantitative measurement in the GVCs toolbox. This was previously a weak point in the GVC literature, but GVC has developed a few metrics including value-added trade by country, although this is achieved through estimation based on the merging of various input-output tables from various countries. [21] In 2008 the estimated value added by Malaysia incorporated into China's total exports was about 7%, but China's contribution to Malaysia's final exports was zero, based on the OECD-WTO Trade in Value Added Database (Cattaneo et al., 2013, p. 16). This estimate is a preliminary indication of Malaysia's participation in the components trade that feeds into China's final goods exports.

In the electronics hardware industry, the platform leaders applying the GVC framework to the computer industry are Microsoft and Intel, while the leading firms that build computers based on their platform technology, firms such as HP and Toshiba, in turn have a group of subcontractors that supply different components or make them under license from HP and Toshiba. Under this power relationship within the computer value chain platform leaders followed by lead firms are the most powerful, as they own the technology and brand name, while subcontracting manufacturers are the least powerful as they own neither.

GVC studies explain comprehensively how production know-how spreads from North America and Japan and later to the East Asian region. Observing the evolution of players in the East Asian regional electronics value chain, Sturgeon and Kawakami (2011) sketch how the Taiwanese electronics manufacturing firms started as subcontractors to North

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[21] Other metrics presented including the participation index, which measures how integrated a country is within the GVC and the distance of production centre to the final consumer index, which is a measure of the fragmentation of production by different industries. The electrical industry is one of the most fragmented industries measured by this index.

American and Japanese computer manufacturer move up the value chain to become brand owners themselves. In GVC terms, the Taiwanese firms have upgraded their industry from captive suppliers in the initial period to lead firms themselves. From there, Taiwanese firms became early movers to China, setting up plants to benefit from China's low labour costs. As a result, technology and production know-how in electronics hardware spreads from Taiwan to China.

Chuang (2016) however argues that the present GVC literature overemphasizes the role of exports in understanding upgrading for indigenous firms in developing country, and considers that not enough research is done on how firms upgrade in response to domestic factors such as how they acquire knowledge of production and respond to local demand. Chuang (2016) cites how the Thin-film-transistor-Liquid-crystal display (TFT-LCD) industry in Taiwan grew from fulfilling domestic demand first before firms stepped up to exporting as an example of domestic demand driving upgrading.[22]

The GVC framework is effective in explaining how production know-how spreads from lead firms to other firms and describes various forms of upgrading. Within the GVC literature, Kaplinsky (2010) case study of Thai cassava shows how China's demand for cassava that has passed through only the primary stage of production resulted in the downgrading of the cassava value chain in Thailand. As a useful contrast, this sectoral study of China's impact in trade and investment in a middle-income country such as Malaysia in a high technology industry (E&E) could inform the broader globalisation literature.

[22] TFT-LCD refers to computer monitor flat screen display.

2.1.5 The Global Production Network

Ernst (2004) describes how the North American electronics industry used East Asian locations such as Malaysia to outsource labour-intensive operations such as semiconductor packaging and testing. As a result the technology and production network spread from North America to, predominantly, Southeast Asia in the 1970s. A paper by Ernst and Kim (2001) on how international business organisations like MNCs organise production provides an early template of the GPN framework which is further developed into its current form by Henderson et al. (2002).

GPN scholars believe that the reality of the fragmentation of international production arrangements is better reflected in a more multi-layered network form such as the GPN than by the GVC in vertical or linear form (Henderson et al., 2002) that connect firms involved in increasingly fragmented production in international trade. Secondly, the GVC focuses on governance within the chain and emphasizes either a producer-driven or a buyer-driven chain, while the reality is more complex than this bi-modal mode (Henderson et al., 2002). However, the GVC has since improved to a model featuring five types of governance in the value chain based on the degree of coordination and power asymmetry among the players (Gereffi et al., 2005). As the E&E industry has a fragmented production structure, the GPN theoretical framework is suitable for use as a component of the theoretical framework for this study.

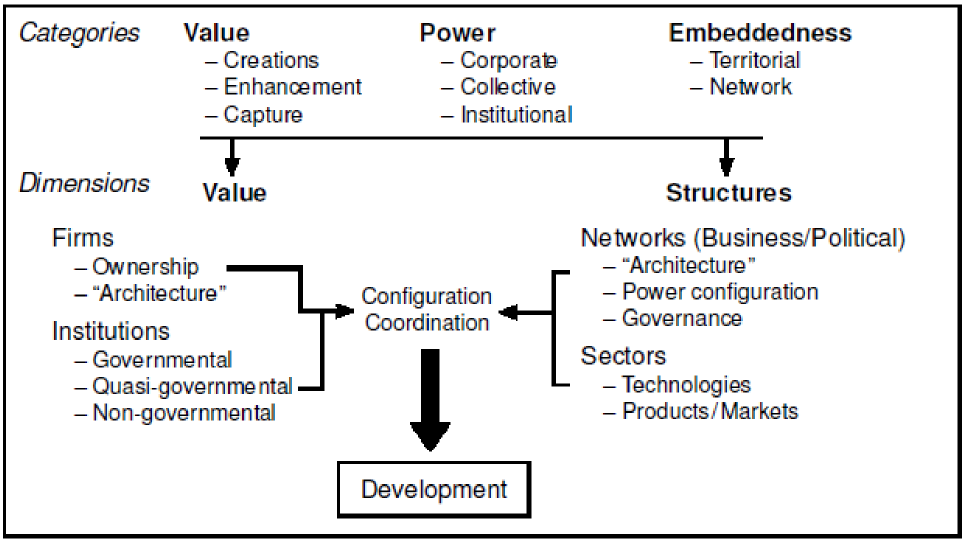
Described as a transnational production network (Parrilli et al., 2013), the GPN is said to provide a more flexible framework than the GVC. The scholars who coined the term 'GPN' were Ernst and Kim (2001). They define it as 'combin[ing] concentrated dispersion of the value chain across firm and national boundaries, with a parallel process of integration of hierarchical layers of network participants' (Ernst and Kim, 2001)in (Henderson et al., 2002).

Following Ernst and Kim (2001) work, Henderson et al. (2002) defines Global Production Network:

> Production networks – the nexus of interconnected functions and operations through which goods and services are produced, distributed and consumed – have become both organizationally more complex and also increasingly global in their geographic extent. Such networks not only integrate firms (and parts of firms) into structures which blur traditional organizational boundaries – through the development of diverse forms of equity and non-equity relationships – but also integrate national economies (or parts of such economies) in ways which have enormous implications for their well-being. At the same time, the precise nature and articulation of firm-centred production networks are deeply influenced by the concrete socio-political contexts within which they are embedded. (Henderson et al., 2002, pp. 445-446.)

The GPN theoretical framework is explained using categories of elements and dimensions or types of actors within the network. Actors within the system interact with the underlying elements to create coordination in the production and delivery of the goods, and this leads to the development of the GPN. A schematic diagram of GPN is provided in Figure 2.1.

Figure 2.1 Schematic Diagram of Global Production Network



Source: Henderson et al. (2002, p. 448)

Value, power, and embeddedness are three principal elements that underlie the functioning of actors such as firms and public sector agencies and networks within the GPN. Value is tangible and can be created, enhanced, and captured. Values are created by firms and can be further enhanced via the transfer of technology between firms, and finally can be captured by the geographical location if it truly benefits the production location. In some cases values created in a particular location might not benefit fully from that location due to ownership structures and tax administration matters.

Next, power includes corporate power, institutional power and collective power. Corporate power refers to firm power, and this can be asymmetrical among the different firms that participate in the network. Institutional power refers to the power of the governing institutions that regulate the trade and production of goods within the network. Examples are trade agreements that govern the rules of the production and trade of goods across borders. Collective power refers to the power of NGOs or related civil movements that can affect the production and distribution network where the network is situated.

The third and final element of GPN is embeddedness. The coordination of production takes place in a geographical region and this is referred to as territorial embeddedness. The second type of embeddedness is network embeddedness, which Henderson et al. (2002) call a process of 'trust-building among [the] network agents' of different producers at different stages of a product.

Dimensions or structure or forms are behind are the second aspect of GPN. Various structures such as firms, sectors, institutions and networks cooperate at different levels Firms are actors that networks together to produce, and different firms occupy different functions within the networks of production with different suppliers. Firms rarely work in isolation and are exposed to sectoral rules such as the labour rules, legal requirements and institutional norms in their area of operation.

Yeung and Coe (2015) update the GPN framework by proposing that the GPN shifts from the concepts of value, embeddedness and power, which are important in GPN 1.0 based on Henderson et al. (2002), to GPN 2.0, which is about cost-capability, markets and finance. Essentially, they try to offer a dynamic model of the GPN based on the driving forces of cost-capability, markets and finance. As the model is dynamic, it discusses the various types of risk faced by the industry. To manage these risks, firms employ various strategies such as intra-firm coordination, inter-firm control, inter-firm partnership and extra-firm bargaining. These different types of strategies have similarities to Gereffi's typology of global chain governance.[23]

Dieter Ernst feels that the Chinese effect on Malaysia's electronics is increased competition, because Malaysia concentrates on low-end assembly and volume-type manufacturing (Ernst, 2004). However, Malaysia's competitive relationship with China may turn out beneficial for Malaysia if China's challenge encourages Malaysia to upgrade. This upgrading of the E&E production network is a major aspect to be explored in this study.

Table 2.5 below summarises the studies discussing China's impact on its neighbours discussed in this chapter.

[23] Gereffi's types of governance in GVC are market, modular, relational, captive and hierarchy. Details are available in Appendix 2.2.

Table 2.5 Type of Studies Discussing the Effect of China

Conceptual Framework	Competitive Analysis	Equilibrium	Equilibrium-Market Clearing	Global Value Chain & GPN
Method-ology	World Market Share	Gravity Models	CGE Models	Qualitative
Key features	Disaggregate total exports into product level analysis. Discern export threat by level of technology.	Quantify China's export impact on countries and the directions of relationship. Quantify China's diversion of FDI from traditional partners to neighbours.	Estimate China's effect on economic growth of neighbours in the future based on circular flow modelling.	Reveal relationship of firms within the stages of production across borders. Firm or network of firms positionality within different stages of production matters.
Source	Lall and Albaladejo (2004), Jenkins (2008), Jenkins (2010)	Trade: Greenaway et al. (2008), Athukorala (2009) Investment: Chantasasawat et al. (2004), Eichengreen et al. (2007), Salike (2010)	Yang (2003), Winters and Yusuf (2007), Ianchovichina et al. (2010)	GVC: Gereffi et al. (2005), Sturgeon and Kawakami (2011) GPN: Ernst (2004)
Malaysia-based Studies	Siew-Yean (2001)			Rasiah and Shan (2012)

Note: Only the most relevant works are listed in the table above.

2.2 Theoretical Framework

The theoretical framework of this study draws on different concepts of competitiveness, spin-off, GVC and GPN to discuss the impact of China using the Asian Drivers framework as its overarching guide. A recent study by Athukorala and Kophaiboon (2014) illustrates this approach: they use market share in conjunction with qualitative discussion about production networks in Southeast Asia. The export data is disaggregated into parts and components, and final goods exports. This export data analysis is then linked with discussion of the functional role shifts in of firms in the production network trade and the FDI pattern in the region. However, Athukorala and Kophaiboon (2014) use the term 'global production sharing' and avoided the GVC and GPN terminology.

The rest of this section specifies the elements in each group of literature such as Asian Drivers, industrial competitiveness, spin-offs, GVC and GPN that are incorporated into the theoretical framework for this study.

2.2.1 Asian Drivers Literature

The Asian Drivers provide the overarching theoretical framework as subject matter and the systematic framework for analysing the impact of China on Malaysia's E&E sector. This includes the direct and indirect impacts of the Asian Drivers, subdividing the type of impact into complementary and competitive. This is the starting point for this analysis.

2.2.2 Industrial Competitiveness

Traditionally, development economists regard the manufacturing industry as a key sector in relation to national competitiveness (Jenkins, 2016). Borrowing from the competitiveness literature discussed earlier, I take a sectoral approach to industrial competitiveness. The basic assumption is that trade in this sectoral perspective is zero-sum among the participants or countries within an exports market This is opposed to viewing international trade at the macro-level of the national economy as a non-zero sum effect. At the national economy level, different sectors react to China's rise and adjust via labour or capital reallocation between different sectors of production. Sectors that will be viable when faced with an influx of cheap imports from China will survive, while sectors that cannot survive will see firms exit and labours being layoff. For example Malaysia can shed labour in the local production of DVD players when faced with an influx of cheap DVD players from China and move to another sector such as automotive production. Conversely, in an industry-based study, job losses and the loss of market share are considered zero sum: China's gain is Malaysia's loss (of jobs and exports market share, as in the DVD example).

However in reality, due to the sheer size of China's market and population, the increase in the production of electronics is inevitable and will most likely surpass Malaysia's production figures anyway. This means that while the elements of non-zero sum assumptions in international trade cannot be totally ruled out, the current structure of international trade and investment in which oligopoly, interactions between various industrial policies and labour market imperfections exist means that there remain valid reasons and space for a sectoral study based on competitiveness assumptions.

Lall and Weiss (2005, pp.4.) provides a detailed explanation of the importance of sectoral analysis of the competitiveness of exports:

> [The] structure of activities and composition of trade matters [because] …there remain benefits from specialization and trade remains a non-zero sum game, but the realisation of the benefits depends on the ability of each economy to create (or attract)

> competitive capabilities and to move into activities that offer the best opportunities for growth, technological development and beneficial spillovers. (Lall and Weiss (2005, pp.4.)).

Jenkins (2016) goes further to say that industrial competitiveness 'can be best indicated by changes in the world market share'. This study adopts a market share analysis for internationally-traded products, with a higher share implying higher competitiveness of the nation's industrial sector in the international arena, and vice-versa. As pointed out earlier, there are some weaknesses associated with studies based on national trade statistics, and my theoretical framework also uses other frameworks such as GVC and GPN to strengthen the analysis.

2.2.3 Spin-off Theory

Spin-offs are an important process in the diffusion of technology from lead firms to new start-ups. Spin-off theory is associated with Klepper (2002) and is used to explain the differences in the pace of innovation of US automobile makers based on mode of entry of a firm into an industry. The paper argues that after learning about the technology it uses, employees of a high-performing firm such as an automobile or semiconductor company leave to form new companies. These new companies may produce the same goods or branch out into something related and new; this is a spin-off. The classic example given to illustrate this point is the fact that most semiconductor companies in the US are spin-offs from Fairchild Semiconductor led by ex-employees such as the founders of Intel, Gordon Moore and Robert Noyce, who left to form their own company.

This spin-off theory is extended to look at the innovations of new entrants compared to 'diversifiers', companies previously involved in activities related to the new branch into which they are now moving. For example in the electronics industry a diversifier is a firm that is already supplying metal precision parts for consumer electronics such as TVs and mobile phones and decides to use its current knowledge to start producing semiconductor testing and inspection machines. Spin-off theory is useful to complement existing explanations about firms upgrading their functions and products within the production network.

Since Malaysia followed the FDI-led model of development, especially in the E&E sector from the 1970s onwards this theory is useful to explain how technology spreads from MNCs to local Malaysian firms. Spin-off technology also complements the GVC and GPN framework in explaining how new clusters of industry are formed, based on participation in the production network.

2.2.4 Global Value Chains

Gereffi (2014, pp.28.) summarises the need for GVCs studies as 'the emergence of GVCs cautions against an overreliance on simple export measures of competitiveness'. The GVC framework also stressed that an industry should be studied beyond trade studies based on traditional national statistics. Secondly, incorporation of the GVC framework furthers the analysis by locating the positions of firms participating in the GVC stages of production. Finally, participation along the GVC is also an important tool for developing countries to get on the development ladder.

The theoretical framework used in this study includes the GVC framework, which is especially useful for discussing different forms of upgrading by firms within the E&E GVC.

2.2.5 Global Production Network

Despite proponents of the GPN claiming its difference from the GVC, the reality is that these two frameworks are interrelated and share similarities. According to Parrilli et al. (2013) the GPN is more inclusive and encompasses a whole sector. Ernst (2004) widens the approach to GPN to include backward linkages industry of the national economy such as supporting industries, arguing that `improved specialization generates pressures to create dense forward and backward linkages within the district or the national economy'. Meanwhile the GVC framework has its own strength in its differentiation of various forms of industry upgrading, although its unit of analysis is confined to firms. Kaplinsky (2016), p.189, quoting Parrilli et al. (2013) sums up the relationship between the GVC and GPN: '… in reality, good GPN research also focuses on the vertical chain relationship, and good GVC research also addresses the embeddedness of local actors and the importance of national and regional innovation systems'. (Kaplinsky, 2016, pp.189.) As such both GVC and GPN are drawn upon together with the other theories discussed earlier to form the theoretical framework for this study.

The study incorporates elements of the GPN framework's embeddedness into the theoretical framework. The concept of embeddedness is very suitable for discussing an industry cluster and how different firms are networked in a sector or geographical location.[24] The concept of embeddedness is also useful to describe how the E&E industry is exposed to various industrial policies and programmes and to institutions where the industry operates.

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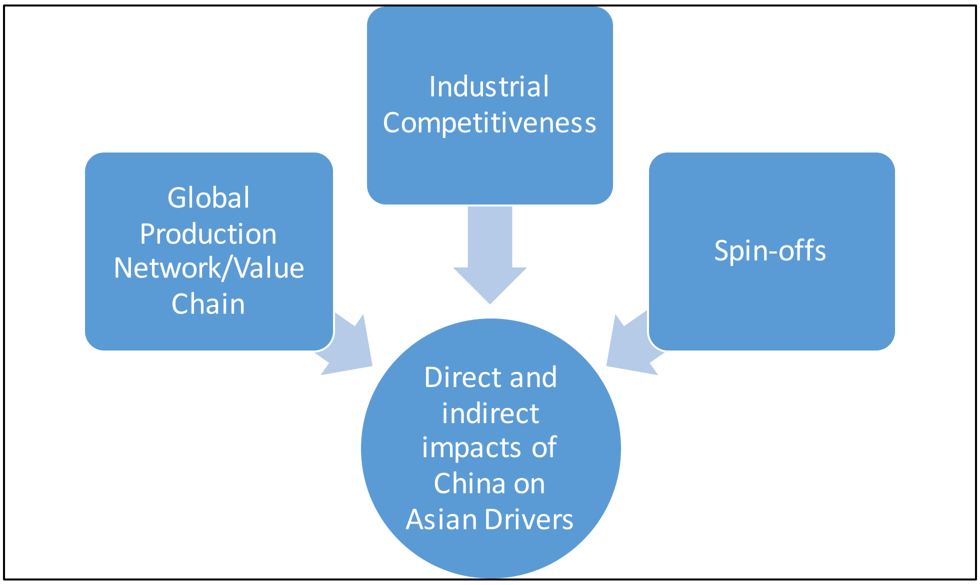
[24] Schmitz and Nadvi (1999) define clusters "as sectoral and spatial concentrations of firms".

2.3 Conclusion and Integrated Theoretical Framework

The theoretical framework of this research is primarily based on the Asian Drivers literature. It also incorporates frameworks developed from the industrial competitiveness, global value chain and global production network and spin-off frameworks. Figure 2.2 presents a simplified version of the theoretical framework used, although in reality the three frameworks interact. [25] The theoretical framework presents the three major underlying theoretical stances used to view the direct and indirect impacts of China on Malaysia's E&E sector.

Figure 2.2 Theoretical Framework: Links between Major Theories



Source: Own Elaboration

In conclusion, the theoretical framework adapted for this study is drawn from Asian Drivers, the competitiveness literature, spin-offs, the GVC and the GPN. This framework allows for a multi-perspective investigation into the research subject at a sectoral level and a comprehensive examination

[25] For example, high impact spin-offs can create new branches of nodes along the GVC/GPN, and this can also have an impact on the competitiveness of the industry as a whole.

of China's impact, moving the focus from the meso to the micro level to understand how linkages of production arrangements in E&E are changing with the rise of China, from a mainly Malaysian point of view.

3.0 Research Methods and Data

The methodology of the study is both quantitative and qualitative. The quantitative methods are primarily based on the adapted market share methods of Lall and Albaladejo (2004), other indexes derived from market share in exports, and some combining both export and import data. The results from the quantitative data indicate which specific E&E products to probe deeper with qualitative interviews. The qualitative method is primarily based on the GPN and GVC frameworks that guide the semi-structured interviews with firms in the E&E sector at field sites.

3.1 Quantitative Methods

The main building block of quantitative methods for this study is the market share method, followed by other trade indexes. According to Jenkins (2016, p.261), competitiveness, an element of the theoretical framework (see Chapter 2), can be linked to the 'composition of exports and in particular to a notion of technological upgrading'.

The market share method is operationalised using a modified Lall and Albaladejo (2004) framework to study trade relationship outcomes at product level based on Malaysia's and China's rising or falling import share at destination markets to understand the effect of China's rise on Malaysia's E&E sector. There are five possible outcomes:

A) Competitive: imports share of Malaysia is falling and China's is rising. Malaysia is losing market share while China has been increasing its market share for the same product line.

B) Mutual Expansion: Import shares of Malaysia and China are rising together, which means they are gaining market share in the same product line. This is positive for both countries.

C) Reversed Competition: Malaysia's share of imports is rising while China's is falling. In this case Malaysia is gaining market share over China and the competition has tilted in favour of Malaysia.

D) Mutual Withdrawal: Import shares of both Malaysia and China are falling as both countries withdraw from the same product line.

E) N.A.: Either Malaysia or China has zero imports in the product line at the beginning and end of the period of analysis.

A summary representation of the possible combinations for outcomes of rising and falling import shares of Malaysia and China at destination market is shown in Figure 3.1:

Figure 3.1 List of outcomes based on rising and falling import share from Malaysia and China at destination market

	Imports share from China rising	Imports share from China falling
Import share from Malaysia rising	B) Mutual Expansion – Imports from Malaysia is expanding together with imports from China. Competitive threat is unlikely	C) Reversed Competition Imports from Malaysia is winning the competition against imports from China
Import share from Malaysia falling	A) Competitive Imports from Malaysia face competition from imports from China	D) Mutual Withdrawal Malaysia and China both face declining competitiveness

Source: Adaptation from Lall and Albaladejo (2004)

An important point here is that the movement between the market shares of China and Malaysia does not claim causality and therefore their mutual expansion is an indirect reference to some form of complementarity, without implying that imports from China to destination markets are causing Malaysia's share of imports to rise or fall. The exercise here shows the relative movements of market shares with directional changes and is henceforth called 'competitiveness analysis'.

The competitiveness analysis calculation covers the period from 1992-2012, evenly split into 1992-2002 and 2002-2012 to show the period prior to and post China's accession to the WTO in 2001. This provides a form of counterfactual of China's impact on Malaysia's industry sectors, comparing situation where China has yet to join WTO with the situation where China is in the WTO.

To discern China's export threat to Malaysia's E&E exports by level of sophistication, a PRODY index based on Hausmann et al. (2007) is used to segment E&E exports by the classification of outcomes based on rising and falling import shares. Next, the classification of outcomes is then regrouped into BEC codes using a concordance table from the World Bank Integrated Trade Solutions (WITS) website. This regrouping by BEC classification allows identification of the different outcomes based on parts and components compared to final goods exports in E&E.

Other than the import share analysis (which I am calling competitiveness analysis), the study uses other indicators and indices to measure competitive and complementary aspects of China's rise on Malaysia's through trade, namely the Balance of Trade, Rate of Import Penetration, Trade Complementary Index (TCI), Index of Competitive Threat (ICT), Revealed Comparative Advantage (RCA) Index, PRODY Index and EXPY Index.

3.1.1 Balance of Trade

In the bilateral trade between Malaysia and China both the balance of trade and the rate of import penetration are based on the comparison of the competitiveness of the imported goods to the competitiveness of the local firms producing the equivalent goods.

The Balance of Trade is given as below:

$$\text{Balance of Trade} = \text{export} - \text{import}$$

Source: United Kingdom Office for National Statistics (2010)

The balance of trade is a measurement of bilateral trade between two countries. The flow of goods between Malaysia and China is either a surplus or a deficit. A deficit in a country's balance of trade can signal a decline in the competitiveness of the economy and a surplus can mean increased competitiveness, subject to further analysis. For this study, as well as the total trade balance I also look at the balance of trade for specific groups of E&E products to get a preliminary grasp of the competition between Malaysian and Chinese producers for the same group of E&E products.

A point to note is that the balance of trade is only a preliminary indicator, as a deficit in certain products is not totally negative for a particular country. For example, if a country experiences a trade deficit in the machinery segment because it is adding new production capacity to produce more exports in the long term, a short term deficit should not be viewed as totally negative. In short, the balance of trade should be viewed in tandem with other indicators over the longer term and within a wider context. In this study, the balance of trade is disaggregated using the BEC to provide a snapshot of the different types of E&E goods traded between Malaysia and China.

3.1.2 Rate of Import Penetration

The next step is to calculate the rate of penetration of Chinese imports into Malaysia's E&E sector to measure the extent to which Chinese exports are affecting Malaysia's E&E firms by industry. The OECD (2010) states that embedded in this rate of import penetration is a comparison of the competitiveness of imported goods to the competitiveness of the local firms endeavouring to maintain their market share. China's import penetration is measured as a percentage of total apparent consumption for products aggregated in a sub-industry within the E&E sector. Apparent consumption is defined as production plus imports minus exports. Production data is obtained from the Monthly Manufacturing Survey of Malaysia's Department of Statistics, while trade data is sourced from UNComtrade through the World Bank's WITS website. The formula for apparent consumption and import penetration is as follows:

$$D = P - X + M$$

where D=apparent consumption, P=production, X=exports and M=imports.

$$MP_{ijc} = M_{ijc} / (P_{ij} - X_{ij} + M_{ij})$$

where MP_{ijc}=rate of import penetration from China
M_{ijc}=value of imports for product *i* in country *j*
P_{ij}=production for product *i* in country *j*
X_{ij}=exports of product *i* in country *j*
M_{ij}=imports of product *i* in country *j*

Source: Adapted from OECD (2010)

The rate of import penetration will show Malaysia's domestic firms' competitiveness compared to the Chinese firms that produce the imports for Malaysia. This method is related to competitiveness theory. By measuring the rate of import penetration of China products into Malaysia I can infer the degree of China's impact on Malaysia's domestic market over time, especially for household electrical products.

3.1.3 The Trade Complementarity Index

The TCI for Malaysia-China bilateral trade gives a sense of the complementarity between the two countries based on the similarity between the structure of one country's exports and the other's imports. TCI is calculated at total trade level and at E&E level for the 1992-2013 period.

The TCI is computed based on:

$$C_{ij} = 1 - \sum (|M_{ik} - X_{ij}| \div 2)$$

where M*ik* is the import share of product *i* in total imports of country *k* and

X*ij* is the export share of product *i* from total imports of country *j*

Source: Adapted from Ng and Yeats (2003)

The TCI produces results between 0 and 1, with 0 when the export of a product from one country is not imported at all by the other country and 1 where the import of country k exactly matches the export from country j. The TCI uses China's import and Malaysia's export data.

The TCI is indirectly linked to competitiveness theory as it is a measure of complementarity (the counterfactual of competitive) between two trade partners, based on their import and export profiles. It is a forward-looking index, specifically looking at the potential of a trade agreement between two countries to see if the imports of one country match the other country's exports. For example if a country exports good *i* and good *i* is imported by a potential trade partner, a trade agreement is deemed potentially beneficial to both trade partners.

3.1.4 The Index of Competitive Threat

Moving from bilateral analysis to world market share approach, in this case Jenkins (2010) Index of Competitive Threat (ICT) measures:

> [t]he extent to which a country faces a competitive threat from China [and] depends ... on the proportion of its total exports accounted for by products in which China is globally competitive. A country that has a high share of its exports in such products is threatened by Chinese competition even if the products concerned account for a relatively small share of China's total exports... (Jenkins, 2008, pp. 1358.)

Jenkins' ICT is used here to measure the scale of the China's threat to Malaysia's E&E exports in 6-digit HS codes. Linked to the competitiveness theory, the ICT captures the interactions between China's share of a particular product in the world export market and the importance of the same product in Malaysia's export basket.

In this research the formula for the ICT is slightly adapted to calculate it in the destination markets using import share. This specific interaction at the product level reveals the level of threat over time on E&E imports from Malaysia by imports from China.

The ICT index at the destination market is given as follows:

$$\text{ICT} = 100 * \sum \left(\frac{\text{X}im}{\sum \text{X}im} * \frac{\text{X}ic}{\text{X}iw} \right)$$

where $\text{X}im$ is the import of product *i* from Malaysia at the destination market
$\sum \text{X}im$ is the sum of all imports from Malaysia at the destination market
$\text{X}ic$ is the import of product *i* from China at the destination market
$\text{X}iw$ is the total import of product *i* at the destination market

Source: Adapted from Jenkins (2010)

The ICT produces a single index, with a higher index number indicating a greater threat from China's to Malaysia's imports at the destination market and a lower index indicating a lesser threat. The theoretical limits of the index are 0 and 100; 0 indicates that either China or Malaysia does not produce or has a zero market share in product *i*. The value of 100 requires both that product *i* is Malaysia's sole product of exports and China has 100% share of the product *i* in the world export market. The theoretical value of 100 is therefore impossible, given that the conditions for fulfilling it are contradictory. In reality the ICT value will have value of less than 100 as a product of multiplication of decimals into decimals. The indexes for *i* products are then aggregated to produce the ICT index for the E&E industry. The ICT is useful to measure the level of threat that Malaysian exports face from the positionality of China's export share at the destination market.

However, the ICT does not gives us the direction of movement of the market share, whether a product's market share has declined or gained over time, and to overcome this the adapted Lall and Albaladejo (2004) method described in the initial part of this chapter is used.

3.1.5 Revealed Comparative Advantage (RCA)

Next, the RCA measures the relative importance of the product within the country's export basket compared to the typical ratio of the product to the world export basket, and infers if a country has the comparative advantage to produce a particular product relative to the world exports average. The RCA is calculated for semiconductor manufacturing equipment (SEM) in Malaysia at product level to identify which type of SEM machines Malaysia is having an advantage in producing.

The RCA is given as:

$$RCA = \frac{Xij}{\varepsilon Xj} \Big/ \frac{Xiw}{\varepsilon Xw}$$

where

X*ij* = export of product *i* from country j, εXj = total export of country j

Xiw = world export of product i, εXw = total world export

Source: Balassa (1965)

If the result of the index is equal to or above 1 the country has a comparative advantage in producing that particular product relative to other countries. If the index is below 1, the country is said to produce relatively less of that particular product relative to the world exports level and does not have a comparative advantage.

Finally, the RCA index is used to measure the competition between Malaysia and China for the same product. For example, if China's RCA score for television products is 3.0 while Malaysia's is 1.1 this means that relative to the respective countries' exports baskets China has 3 times the average share of television products in world exports while Malaysia has 1.1 times the world average, it still lags behind China's comparative advantage. This indirectly reflects the relative importance of the nations as exporters of a specific product.

The RCA is often criticized for not reflecting the true comparative advantage because exports pattern can be often distorted by government subsidies or taxation either to encourage or discourage the export of certain targeted products. However, the RCA is taken as a preliminary indicator that paves the way for more detailed qualitative discussion in this research.

3.1.6 The PRODY index

This study disaggregates the trade structure of China and Malaysia by level of sophistication using the PRODY index. The PRODY index is calculated at the 6-digit level of HS 1998/92 Nomenclature for all E&E products by the researcher.

Based on Hausmann et al. (2007), the PRODY index is a 'weighted average of the per capita GDPs of exporting country' earned from a specific product. PRODY for product *k* for as follows:

$$\mathrm{PRODY}_k = \sum_j \frac{(x_{jk}/X_j)}{\sum_j (x_{jk}/X_j)} Y_j$$

where (x_{jk}/X_j) is the value share of product *k* in country *j*'s total exports

$\sum_j (x_{jk}/X_j)$ is the sum of all value shares of all countries exporting product *k*

Yj is the per capita income of country *j*

Source: Hausmann et al. (2007)

The PRODY index captures the associated income behind a specific product being exported. For the weight, the numerator (x_{jk}/X_j) captures the share of the product in the total national export, while the denominator $\sum_j (x_{jk}/X_j)$ captures the value share of the same exported product of all countries to world exports. The weight is then multiplied by the per capita income of the country, Y*j*. The PRODY index produces absolute figures, with higher per-capita income countries and higher market share expected to produce higher figures, indicating greater sophistication of exports. In the case of lower value shares of the export of a developing country, a lower PRODY index is expected. Finally, all PRODY indexes for each country *j* are summed up to produce a single PRODY index for each product *k*. Some manual adjustments are made to the PRODY index to reduce bias, such as dropping island nations that do not have any real manufacturing facilities but usually serve as offshore financial centres for book-entry transactions.

The PRODY index is used to rank the measure of sophistication of each export product in the E&E sector. A higher PRODY index indicates higher and a lower PRODY index indicates lower sophistication of the product. The PRODY indexes for each product for every year are aggregated and then averaged to produce the PRODY value for the period of 1992-2012. Based on the average PRODY index, the 338 products in the E&E sector are ranked and then divided into four quartiles, with Quartile 1 the most and Quartile 4 the least sophisticated. Next, a product code with its corresponding type of outcome (competitive, mutual expansion, reverse competition, mutual withdrawal) is grouped into quartiles of sophistication. The import share of each product in the same outcome category, within its specific quartiles, is then summed up. The purpose of disaggregating the competitiveness analysis with PRODY index is to observe the different outcomes categories of Malaysia's E&E exports, based on level of sophistication, for the periods 1992-2002 and 2002-2012.

The segmentation of E&E exports by PRODY index allows me to 'thin slice' the export structure by level of sophistication, in contrast to Lall and Albaladejo (2004) methods of disaggregation export structure into low, medium and high technology, the whole electronics sector is classified as high technology. By separating the products according to their sophistication the export data helps us to understand the changes in Malaysia and China's E&E exports shares by level of sophistication, which then allows inference of the product's upgrading over time. This links the competitiveness theoretical framework with the GVC framework explained in Chapter 2.

3.1.7 The EXPY" Index

Developed by Hausmann et al. (2007), the EXPY index is the weighted sum of the PRODY index of each product exported by a country, using the share of each product in the country's total exports as weight. The EXPY index gauges the level of productivity linked with a country's exports basket. The EXPY index formula for country *i* is as below:

$$\mathrm{EXPY}_i = \sum_k \frac{x_{ik}}{X_i}\ \mathrm{PRODY}_k$$

Source: Hausmann et al. (2007) and McCann (2007)

The EXPY index for country *i* is the sum of all PRODY index *k* weighted by the simple share of product *k* in the exports of country *i*. The higher the EXPY index indicates the higher the sophistication of a country's exports.[26]

[26] The EXPY index may underestimate the sophistication of a country's exports basket if a very high-technology product is passed on for assembly in a low GDP per-capita income country. This is because one of the main components of PRODY is GDP per capita income. However, this problem is mitigated when comparing two developing countries such as China and Malaysia, which happen to have a comparable GDP per capita income.

The EXPY index is adapted to measure the sophistication of Malaysian and Chinese imports to their respective destination markets. The adapted EXPY index is denoted as EXPY" gauges the level of productivity linked with a country's imports basket at E&E level for 338 products. The main difference is that the weight denominator is total E&E rather than the usual total exports. The EXPY"' index formula for country *i* is provided below:

$$\text{EXPY'''}_i = \sum_k \frac{x_{ik}}{\sum x_{ik}} \text{PRODY}_k$$

Source: Adapted from Hausmann et al. (2007) and McCann (2007)

The EXPY"' index for country *i* is the sum of all PRODY indexes *k* weighted by simple share of product *k* in the total E&E imports from country *i* in a particular destination market. Therefore, the EXPY"' is the sum of weighted PRODY of each E&E product to total E&E imports in a destination market. A higher EXPY"' index indicates a higher E&E import sophistication from a particular country in the destination market.

3.2 Data sources

The analysis, based on an adaptation of Lall and Albaladejo (2004) WMS method, is divided into two periods, 1992-2002 and 2002-2012; 2002 is the strategic mid-point in the period of analysis as it covers periods of equal length before and after China's accession to the WTO. The data is analysed at the 6-digit level of HS 1988/92 product codes for E&E, which consists of 338 products out of 5,038 product lines of the total trade. For the full list of E&E products see Appendix 3.1.

The main data sources used in the analysis are trade data and GDP per capita. Trade data, which is used to construct the weights, is sourced from UNComtrade through the World Bank WITS website, while real GDP per capita data is sourced from the World Bank Development Indicators website. Foreign exchange rates for Malaysian ringgit and US dollar are based on the Central Bank of Malaysia's website. Production data is based on the monthly manufacturing survey compiled by Malaysia's Department of Statistics. For a list of Malaysia Standard industrial Classification codes cover under this study, please refer to Appendix 3.2. Approved manufacturing investment data was collected from Malaysia's Investment Development Authority (MIDA) via personal interview.

For E&E products, the data coverage for products includes the conversion from SITC Rev.3 codes to HS 1988/92 Nomenclature was made using the conversion table provided by the World Bank WITS website. This is because HS1988/92 allows a longer series of data to be examined than other revised Nomenclatures; for example HS 2007 Nomenclature only contains trade data from 2007 onwards. Items listed under the SITC Rev.3 Codes in Chapters 75, 76 and 77 are co-opted into the E&E industry category using the HS codes of 1988/92 to ensure proper coverage of E&E products. This is because Malaysia's Department of Statistics defines E&E exports as the sum of the products listed under Chapters 75, 76 and 77 of SITC Rev.3 Nomenclature. There are some limitations to converting the HS Codes to SITC Rev. 3, as indicated on the UNComtrade website, but it is the best conversion table available.

HS codes at the 6-digit level are selected for better data precision than HS codes at 4-digit level, which generally lump the final products with their parts and components.

The TCI is calculated at the E&E level with a total of 54 product lines using HS codes at the 4-digit level. For a detailed list see Appendix 3.3. The E&E sector in the TCI differs slightly from the E&E category in the competitiveness analysis that uses HS Codes at 6-digit level. HS codes at the 4 digit level were used for TCI instead of the 6 digit level because the index obtained at the latter became biased as some products reported zero in export data due to discontinuity at the end of the period. Calculating the index using more aggregated data at the 4-digit level minimises the problem of the missing data biasing the index. However, the interchangeability between some 6-digit HS codes and 4 digit HS codes is not seamless, as some 6-digit HS codes do not add up to the HS Codes at the 4-digit category at group level. Effort has been made to ensure that the codes are as comparable as possible by retaining those where the sum of the 6-digit HS codes matches the aggregated 4-digit HS codes. On average, about 2.0 per cent of the total E&E export value of 338 products is excluded in the E&E category of the TCI. Exclusions include air-conditioners, refrigerators, dryers and other items, due to the non-interchangeability from 6 to 4-digit HS codes.

Reports such as government policy documents and unpublished market analysis by trade associations were obtained through the Internet via an exploratory search or collected during fieldwork visits to interviewees' organizations.

3.3 Qualitative: Semi-structured interviews

The quantitative analysis revealed the segments of the E&E industry to be focused on. For example, the quantitative analysis shows that IC is Malaysia's most valuable export product and the ICT shows the threat from China increasing over the years.[27] Therefore the IC industry offers an interesting GVC/GPN study with qualitative interviews. Related key works here are Ernst (2004) and Sturgeon and Kawakami (2011) on the electronics sector.

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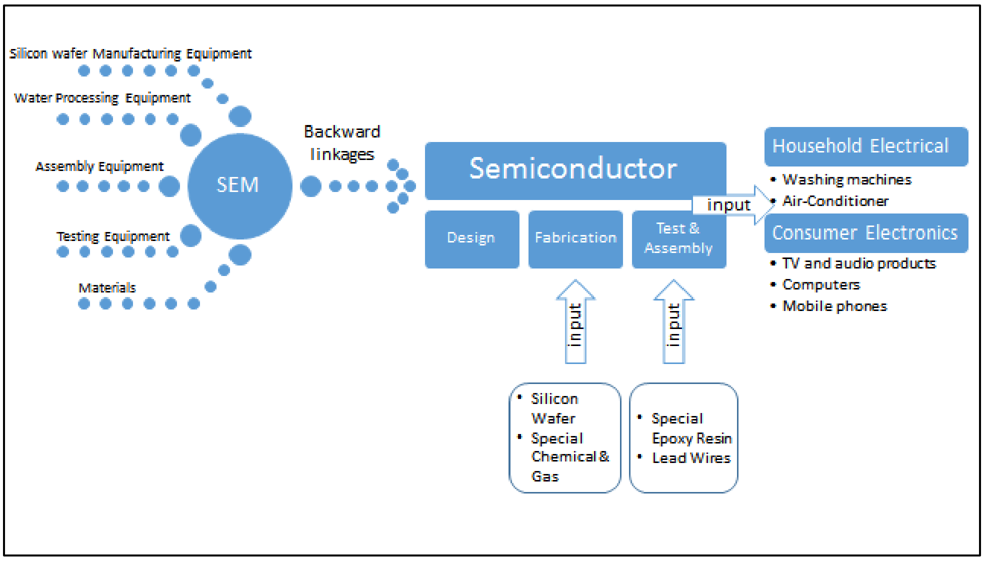
[27] Refer to Chapter 6, Figure 1 and other results in Chapter 6.

Based on the theoretical GVC/GPN framework, a schematic representation of the qualitative methods is shown in Figure 3.2 below. The study encompasses the backward linkages of the semiconductor industry, the semiconductor industry itself and the semiconductor user industry, namely the household electrical products industry.

Figure 3.2 Malaysia's Electronic and Electrical GPN at the sectoral level



Note: SEM is Semiconductor Equipment Manufacturer
Source: Based on Global Production Network

From the quantitative works to identify important subsectors, the qualitative method of the research is deployed with semi-structured interviews based on the GVC framework related to works by Kaplinsky and Morris (2001), and Global Production Network related to works by Ernst (2004). These interviews targeted key actors in government departments, trade associations and firms, including lead firms and their suppliers. The GVC/GPN theoretical framework works by linking different actors along the chain, or in GPN language, understanding the links between the nodes. Therefore the interviews were used to reveal the type of relationship between suppliers with lead firms such as MNCs (Kaplinsky and Morris, 2001).

The qualitative interviews take further the analysis in this study, for example by identifying market segmentation within the same product code under quantitative market share findings (Kaplinsky and Morris, 2001). For example, if two subsidiaries of an MNC operate in different locations but export ICs under the same trade codes, the way to find out or validate which plant is exporting the most sophisticated ICs can be confirmed through semi-structured interviews, which can also reveal the unwritten rules within the value chain. For functional upgrading, the qualitative interviews reveal detail role a subsidiary at different locations is providing within a global entity. Overall, the use of interviews is useful to generate more insight into the subject researched. Interview prompt sheets were used (see Appendix 3.4, 3.4, 3.5, 3.6 and 3.7).

The data from the GVC/GPN qualitative interviews was then used in triangulation with the statistical analysis and official government documents to back the findings in relation to the research questions and check for consistency among the different sources of information.

Interviewees in this study are from the IC, household electrical appliances industries and Semiconductor Equipment Manufacturer (SEM). These three sub-industries were selected because the IC is the most important export item in the E&E sector and the semiconductor has historically been the mainstay of Malaysia's exports since the early 1970s. The household electrical appliances industry was selected because it includes a mixture of local Malaysian players and finally, for SEM, is where some of the most dynamic Malaysian-owned firms are growing and this is an under-researched area. Interviewees included key actors in industries and the Malaysian government sector.

Fieldwork was conducted in two phases in Malaysia and China during 2014. As a start, a list of firms in Malaysia was obtained from Collaborative Research in Engineering, Science & Technology (CREST), the Electrical and Electronics Association of Malaysia (TEEAM) and Invest-in-Penang Bhd. (InvestPenang). Based on purposive sampling, a total of 38 semi-structured interviews were conducted, 34 in Malaysia and a further four in China. The breakdown of the respondents by category is shown in Table 3.1.

Table 3.1 Respondents by Type

	Academic	Manager (firm)	CEO (firm)	Trade Assoc.	Gov't Official	Consultant
Malaysia	3	7	8	1	13	2
China	0	2	1	0	1	0

At the firm level in Malaysia the interviewees included 13 CEOs and managers in the IC industry, of which three were from the Electrical sub-sector. At least two respondents were co-founders of their companies, providing insights into their start-up phases. While the interviewees in China were few, I compensated wherever possible by visiting areas such as the Shenzhen High-Tech Park, which is a hotbed of E&E innovation mentioned by senior MNC and start-up managers in Malaysia. The interviews conducted in China interestingly provide a reverse perspective on the competitive/complementary question in Malaysia, besides providing detailed information of industrial policies in China at the implementation level from the firms' perspective.

In the data-analysing phase, data from the semi-structured interviews, newspapers and official documents and statistical information obtained during the fieldwork were triangulated to draw inferences. Information expressed in the interviews was then validated with newspaper reports or government official documents or corporate annual reports. Secondary data was searched based on purposive exploratory examination as per Hobday and Rush (2012), following the information trail based on the interviews and academic journals to explore further firm-level information through the Internet, mindful of the differing quality of different types of sources. Data collected from the semi-structured interviews was then triangulated with information available from company websites and further interviews with stakeholders such as government agencies and industry experts (Kubny and Voss, 2014). A list of the interviewees is available on the examiners' request. Views expressed by Malaysia's public sector interviewees with regard to industrial policy at programme level are also included.

3.4 Limitations

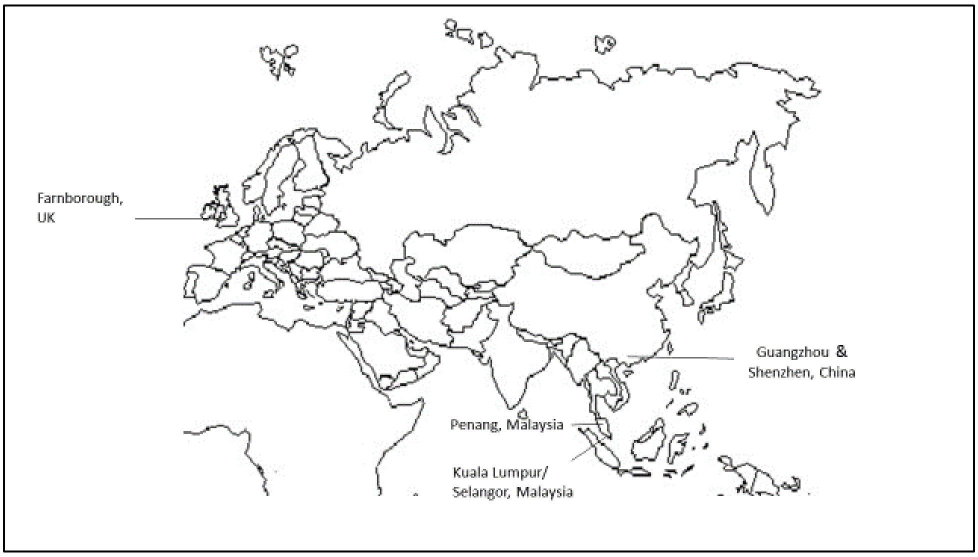
The quantitative methods used in the study have two limitations. Firstly, current trade data could only capture the value based on product identification because it is based on gross output or the value of the exports rather than value added. In other words, the trade data could not capture the associated value at each stage of the manufacturing process. This raises the possibility that in evaluating China's impact on Malaysia's E&E industry China's sophistication in the exports baskets can be overstated if China only captures a small share of the value added to its high technology exports. Finally, as this study adapts the Lall and Albaladejo (2004) method of rising and falling export shares from Malaysia and China it is unable to claim the causality of China's effect on the rise or fall of imports share from Malaysia, but presents the relative movements of market share linked to industrial competitiveness.

The qualitative interview faces constraints such as access to key actors and non-disclosure agreements (NDA) between firms in the GPN. Access was difficult, as the interview targets were senior managers who are highly selective about granting interviews to researchers. Access for interviews was even more critical in China after labour issues cropped up at Taiwanese-owned factories based in China that are contracted to manufacture goods for a famous US-based MNC came under the spotlight not long ago. Secondly, NDAs signed between firms who supply major MNCs make GVC or GPN studies more difficult because firms cannot disclose that they are supplying components to a specific company. This limits the conversation, as the respondents make conscious decisions not to discuss the names of suppliers and clients during the interview. To overcome this I performed a search for a tear-down (disassembling the mobile phones to reveal the parts and components) of the mobile devices from computer magazines and technology gadget websites to trace the GVC/GPN using triangulation with the data obtained from interviews.

3.5 Study Location

The primary locations of the fieldwork in February to May 2014 were the state of Penang and the Kuala Lumpur/Selangor area, where the E&E industry is predominantly based in Malaysia. The second phase of fieldwork was carried out in the second half of 2014 in the Guangzhou-Shenzhen area in southern China. The main locations of the fieldwork were in Malaysia and China; an electronics and machinery trade fair in the UK was also attended to understand the various machineries used in the production of electronic devices via discussion with exhibitors. Figure 3.3 below, shows a map of the field research sites.

Figure 3.3 Fieldwork Research Sites



Summing up, the study deployed both quantitative and qualitative methods to answer the research questions. Initially the quantitative findings identified the segment of products to target for qualitative interviews at the firm level in Malaysia and China. The findings from the quantitative study were triangulated with qualitative interviews, policy documents and other secondary sources for consistency.

4.0 Evolution of Malaysian and Chinese E&E Industries

This chapter describes the development paths taken by Malaysia and China in developing their respective E&E industries, as background information to inform the discussion in Chapters 5, 6, 7, and 8. Towards the end of the chapter the contrasting of Malaysia and China's different strategies for developing their industries also informs the industrial policy area within the economic development literature.

The chapter begins with a discussion of the development of Malaysia's E&E industry from the 1970s to the present day, followed by that of China's E&E industry since the opening up of China in the early 1980s to the present day. Product-wise, semiconductors and small household domestic appliances are discussed for both countries. The chapter also briefly touches on the computer industry in the electronics sector and on the television industry. Malaysia and China followed different paths to develop their E&E industries and ended up very differently in terms of outcomes.

Malaysia and China are both developing countries but their E&E industries are at different levels of development. China is already the world's top electronic and electrical goods exporter, as indicated by its export figures for semiconductors, PCs and TV market. China has a large population and is more heterogeneous in terms of development than Malaysia which, despite lower GDP and export figures, has higher per capita GDP at US$10,628.0 compared to China's US$6,991.9. Table 4.1 below, presents the details.

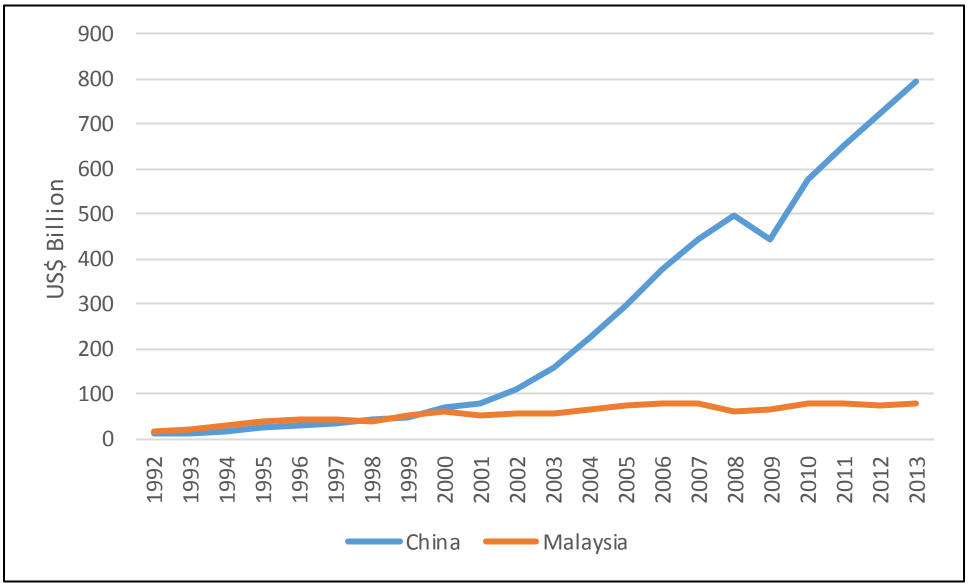
Table 4.1 Malaysia-China Comparison Indicators

2013		
General Indicators	**Malaysia**	**China**
GDP (current US$ Bn)	313.2	9,490.6
GDP per capita (current US$)	10,628.0	6,991.9
Population (millions)	29.5	1,357.4
E&E industry		
E&E exports* (US$ Bn)	77.0	796.3
IC exports (billion units)	0.3	4.5
PC Shipment (million units)	1.8	338.7
TV production (million)	17.1	127.7

Note: * based on 338 products. Full list of products available in Appendix 3.1.

Source: Based on data from World Bank, UNComtrade, Central Bank of Malaysia, China's Statistical Yearbook

Figure 4.1 Malaysia and China's World Exports of E&E Products



Source: UNComtrade

Figure 4.1 above presents world E&E exports by Malaysia and China. As a general observation, Malaysia's and China's value of E&E exports were rising together in 1992-2013 period. The rise of Malaysia's E&E exports is not obvious as the scale of the vertical axis in the graph is dwarfed by the exponential increase in Chinese E&E exports, but Malaysia's E&E exports are still increasing, albeit at a lower rate. Secondly, Malaysia and China almost have an equal starting point in 2000, but China's E&E export growth diverges from Malaysia's after China joined the WTO in 2001. China's E&E exports are worth US$796.3 billion in 2013 compared to Malaysia's at US$77.0 billion.

4.1 Malaysia's and China's role in the Electronics Global Production Network

Malaysia's regional role in the production of E&E products shifted from being a location for labour-intensive production for North American, European and Japanese MNCs since the early 1970s to focusing on manufacturing parts and components in the decade of 2000. In the 1990s, Malaysia also had a sizeable finished goods industry, making electronic equipment such as computers and other household electrical goods, particularly through the presence of Japanese FDI from companies such as Panasonic, Sanyo and Sharp. However, Malaysia's finished goods segment has been contracting since the middle of the 2000s due to China's increasing role as a final assemblers in the regional production network, of which more details are provided in Chapters 5 and 6.

Regionally, Malaysia supplies E&E components to China for final assembly. Today, Malaysia continues to play the role of an assembly and packaging centre for North American electronics in the IC industry, but is increasingly automating its production lines, making Malaysia increasingly specialised in semiconductor exports. This specialisation shows early signs that the E&E value chain in Malaysia is upgrading.

In the 1980s, China started as a processing trade centre or mainly assembly operations for E&E industry, similar to Malaysia's role in the early 1970s, with the opening of the Export Processing Zones. Currently China is still the centre for E&E assembly in the East Asia region (Athukorala and Kophaiboon, 2014). It has the greatest capacity in the world for the production of electronic products such as mobile phones, computers, colour TVs and digital cameras. As shown in Table 4.2 below, global production capacity for electronic products continues to shift into China This also makes China the world's main consumer of semiconductors as ICs are a main component in electronics. As an unintended consequence, China is facing a bigger trade deficit in ICs than in oil.

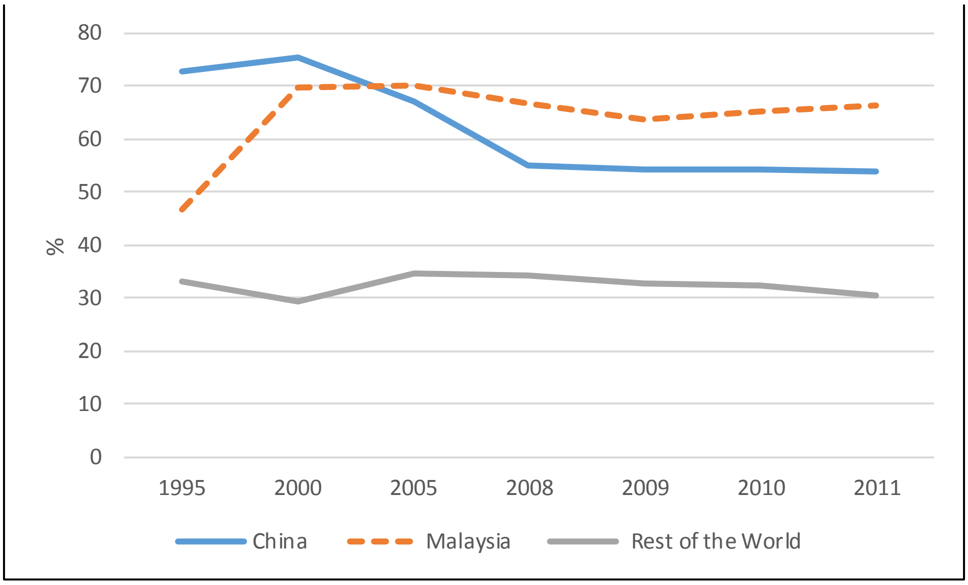
Table 4.2 China's share of production capacity for selected electronic products worldwide, 2008-2013

	%					
Products	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Mobile Phone	44.7	49.9	62.7	63.8	67.7	80.6
Computer/ PC	47.0	60.9	73.4	74.0	70.8	62.8
Colour TV	43.9	48.3	47.8	48.6	53.8	56.7
Digital Camera	-	62.3	64.9	-	-	-

Source: PricewaterhouseCoopers (January 2015, p. 11.)

Although China was initially dependent on foreign investors to drive its exports, it is showing signs - based on falling shares of foreign value added in gross exports, as shown in Figure 4.2 below - that it has localised its backward linkages and its supporting industry. Its share of foreign value added in gross exports in electrical and optical equipment) falls from 70.0 per cent in 1995-2000 period to below 60.0 per cent from 2008 onwards. However, caveats apply to the results based on the OECD-WTO Trade in Value-added Database: this is an estimation based on the merging of different countries' input-output tables, and as such does not distinguish between production by foreign MNCs based in China and production by indigenous Chinese firms in China.

Figure 4.2 Share of Foreign Value Added in Gross Exports (electrical and optical equipment) (%)



Source: OECD-WTO Trade in Value-added Database

While China has been more successful in localising the backward linkages of its electrical industry, Malaysia's role in the production network is to supply more sophisticated IC chips than China's based on unit value analysis. IC chips, or *monolithic integrated circuits, digital* (HS 854211), are the most important exports from Malaysia's E&E industry. Based on interviews with an MNC based in Penang (referred to here as Corporation A) that manufactures microprocessors, Malaysia specialises in the assembly and testing of higher-end chips while lower-end chips are tested and assembled in China and Vietnam. Penang is exporting microprocessors of higher value and specifications, which are priced higher and are destined for end use in computer servers. China and Vietnam on the other hand focus on manufacturing IC chips for the company for lower segment markets. As a rule of thumb, the electronics industry generally refers to the lower segment of the electronic devices where IC chips are made for tablets priced at US$100 or less. Although Corporation A has a fabrication plant in China and fabrication is technically a higher function than testing and assembly, the fabrication plant produces ICs for the company that using manufacturing technology that are considered two generations earlier than the current industry-wide specification. (Corporation A, corporation brochure).

A unit value analysis was carried out to validate the qualitative information that Malaysia is exporting higher-value IC chips than China, which indirectly infers the upgrading of Malaysia within the IC industry. If it is true, IC exports from Malaysia should have a higher unit value than China's, as alluded during the interview with Corporation A (interviewee 1). Admittedly, this is a crude exercise because the prices of ICs will have to be based on a geometric mean, but a detailed breakdown by type of IC is not available in the UNComtrade database. Therefore an indirect way to check whether Malaysia's IC exports have a higher price than a ICs exported from China is to use the unit value. The unit value for digital ICs is used here as a proxy for the price as shown in Table 4.3 below.

Table 4.3 Unit Values in US$ of Malaysian and Chinese Monolithic Digital Integrated Circuits (HS 854211)

Year	Malaysia Unit Value	China Unit Value	Difference
1992	0.10	0.64	-0.53
1993	0.11	0.27	-0.16
1994	0.13	0.45	-0.32
1995	0.61	0.96	-0.34
1996	1.07	0.36	0.71
1997	0.84	0.28	0.56
1998	0.72	0.26	0.46
1999	1.13	0.26	0.87
2000	1.04	0.33	0.72
2001	1.43	0.25	1.18
2002	1.29	0.77	0.52
2003	1.08	0.88	0.20
2004	0.96	0.98	-0.02
2005	0.99	0.96	0.03
2006	0.74	0.88	-0.14
2007	1.03	0.81	0.22
2008	0.68	0.71	-0.02
2009	0.70	0.60	0.10
2010	0.67	0.52	0.15
2011	0.95	0.56	0.40
2012	0.83	0.22	0.61
2013	n.a.	0.22	n.a.

Note: The quantity for of Malaysia's export of monolithic digital integrated circuits (HS 854211) in 2013 is not available.

Source: Based on UNComtrade data

Barring the transfer pricing issues, based on a statistical t-test for one-tailed two mean at 0.01 significance level, the average unit value of Malaysia's *monolithic integrated circuits, digital* (HS 854211) from 1992-2012 is higher than the average unit value of Chinese exports of the same product. HS 854211 is the trade code for digital microprocessors. Similarly, the results at 0.01 significance level of two means t-tests for monolithic digital circuits, non-digital (HS 854219) also confirms that the average unit values from 1992-2012 of Malaysia's IC chips is higher than that of China's exports.[28] Examples of HS 854219 are analogue chips such as radio-frequency chips or sensor chips. However, for *parts of electronic integrated circuits* (HS 854290), China actually has higher an average unit value than Malaysia's for most of the years. The hypothesis test result, at 0.01 significance level, cannot allow us to conclude that the unit value of China exports is higher than Malaysian unit values for *parts of electronic integrated circuits*.[29] Details of the share of contribution of 6-digit HS codes in the IC Chips category (HS 8542) are provided in Appendix 4.4.

4.2 Evolution of Malaysia's E&E industry

In the regional context Malaysia industrialised late with Thailand and Singapore in the 1970s after Japan, Korea, and Taiwan had industrialised much earlier in East Asia. Malaysia's economic structure was transformed as a result of its industrialisation, beginning in the 1970s, when manufacturing only made up of 13% of total value added in the country's GDP, and peaking in 2000 at 31% of GDP before declining to around 23% of total GDP in 2013. Details are presented in Table 4.4 below.

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[28] Unit value for HS 854219 available in Appendix 4.1 and unit value for HS 854290 as shown in Appendix 4.2. Detailed statistical results of hypothesis testing are available in Appendix 4.3.

[29] It is noteworthy that the variance in the unit values in Malaysia's export data is high on yearly basis for *Parts of electronic integrated circuits* (HS854290), and therefore the results of statistical test for HS854290 must be read with caution.

Table 4.4 Share of Malaysia's GDP by Activity (%)

	%			
Year	Manufacturing	Agriculture	Other	Total
1955	8	40	52	100
1960	9	38	53	100
1965	10	32	58	100
1967	12	31	57	100
1969	12	33	54	99
1970	13	31	56	100
1975	16	28	56	100
1980	20	23	57	100
1985	20	21	59	100
1990	27	19	54	100
1995	26	13	61	100
2000	31	9	61	100
2005	30	8	62	100
2010	26	11	63	100
2011	26	12	62	100
2012	23	10	67	100
2013(e)	23	9	68	100

Note: (e) = estimated.
Source: Data from 1955-1990 based on Alavi (2002, pp. 30.), the rest based on data from Department of Statistics of Malaysia

When Malaysia industrialised in the 1970s, the E&E sector was the main manufacturing activity driving the industrialisation. Based on Table 4.5 below, when industrialisation began in 1970 E&E only represented 5% of total value added in manufacturing. E&E experienced high growth in the 1970s and '80s, with its share of total value added in manufacturing peaking at 30% in 2000, and thereafter its contribution to the share in value added in the manufacturing sector declined, falling to 22% in 2012.

Table 4.5 Share of Value Added in Malaysia's Manufacturing Sector (%) 1960-2012

Industry	1960	1970	1981	1990	2000	2005	2010	2012
Processing-off estates	37	11	n.a.	5	3	4	6	7
Food	12	16	9	6	4	4	5	5
Beverages	3	4	3	2	1	1	1	1
Tobacco	3	7	3	1	1	0	1	0
Textiles & Apparel	1	2	5	3	2	1	1	1
Footwear	-	0	0	3	2	1	1	1
Leather & Leather Products	1	1	2	0	0	0	0	0
Wood Products	8	10	9	6	4	3	3	2
Furniture & Fixtures	2	1	1	1	2	2	2	1
Paper & printing products	0	7	5	5	4	4	3	3
Chemical & Products	10	9	5	11	8	13	12	10
Petroleum & Coal Products	-	4	6	3	7	14	18	20
Rubber & Plastic Products	4	4	14	5	3	2	3	3
NMMP	4	7	5	5	3	3	3	3
Basic Metal	2	3	3	4	2	2	4	4
Metal Products	9	4	4	3	4	4	4	4
Electrical & Electronics	-	5	17	21	30	26	17	22
Transport	-	3	5	5	4	4	6	6
Machinery except electrical machinery	-	-	-	4	9	3	3	3
Other	7	2	4	6	8	7	6	5
Total (%)	100	100	100	100	100	100	97	100
RM Bn in Current Prices	0.4	1.2	8.7	24.5	88.2	118.2	170.7	204.2

n.a. = not available, NMMP = non-metallic mineral products
Source: BNM Monthly Statistical Bulletin, July 2015

Apart from being an important sector for its share of total value added in manufacturing, the E&E sector is responsible for about 40% of total manufacturing jobs (EPU, 2010, p. 131).[30] In 2014 it also contributed around 49% of total manufactured exports or 32.9% of total Malaysian exports (MATRADE Malaysia, 2015).[31] Since 1970, based on its share of value added in manufacturing, manufactured exports and employment, Malaysia's E&E industry become a very important industry in terms of both size and employment. Table 4.6 below, further illustrates the components and goods produced by Malaysia's E&E industry in 1988-2013.

Table 4.6 Output of Selected Electronics and Electrical by Unit, 1988-2013

E&E Products	1988	1990	2000	2010	2012	2013
Integrated circuits (million units)	4,709	6,084	21,424	38,007	39,391	35,686
Semiconductors (million units)	2,182	2,565	16,373	17,997	19,765	19,281
Electronic transistors (million units)	5,545	5,956	17,519	34,184	36,119	35,362
Telephone and telegraph cables (tonnes)*	4,667	10,757	22,524	n.a.	n.a.	n.a.
Insulated wires and cables (tonnes)	16,936	33,623	73,673	61,046	69,610	86,384
Television sets (million units)	1.2	3.2	10.6	13.2	13.1	17.1
Room air-conditioners (million units)	0.7	1.0	1.9	2.6	2.7	2.6
Radio (thousand units)	21,070	37,019	36,348	57,350	28,365	18,954

Note: * Cable reports discontinued by Department of Statistics in 2010

Source: Monthly Statistical Bulletin, January 1998 and July 2015, Central Bank of Malaysia

This section discusses first the electronics industry and then the electrical industry. In terms of manufactured exports structure, the electronics industry contributes much more than the electrical industry (household electrical items). For example, based on Table 4.7 below, exports of

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[30] Based on the latest Manufacturing Survey 2013 from DOSM, using 2012 as a reference year.

[31] Manufactured exports is the sum of sections 5 (chemicals), 6 (basic manufactures), 7 (machinery and transport equipment), and 8 (miscellaneous manufactured goods), excluding division 68 (non-ferrous metals) under Standard International Trade Classification (SITC) by United Nations Statistics Division. Total exports refer to the summation of all sections within the SITC classification.

semiconductors in 2013 totalled 42% and the electrical sector totalled 21% of total E&E manufactured exports. The electrical sector is made up of mainly audio-visual consumer electrical products (7% of total manufactured exports), mainly air-conditioned electrical industrial machinery and equipment (12%) and small electrical appliances (2%).

Table 4.7 Share of Sub-industries in Total E&E Industry and Total Manufactured Exports

Year	1975	1980	1990	2000	2010	2012	2013
Electronics							
Semi- conductors	0	76	44	31	36	40	42
Electrical machinery & appliances*							
Electronic equipment & parts	0	9	14	42	36	30	29
Consumer electrical products	0	4	21	11	10	7	7
Industrial & commercial electrical products	0	4	13	10	8	10	9
Electrical industrial machinery & equipment	0	8	8	5	9	11	12
Household electrical appliances	0	0	0	0	1	2	2
Total E&E	100	100	100	100	100	100	100
E&E as % of total manufactured exports	25	48	57	72	56	49	48
Total Manufactured Exports (RM Bn)	-	6.3	46.8	317.9	486.9	519.9	549.3

Note: The table above cannot be directly compared to the monthly external trade statistics published by Malaysia's Department of Statistics due to differences in classification.

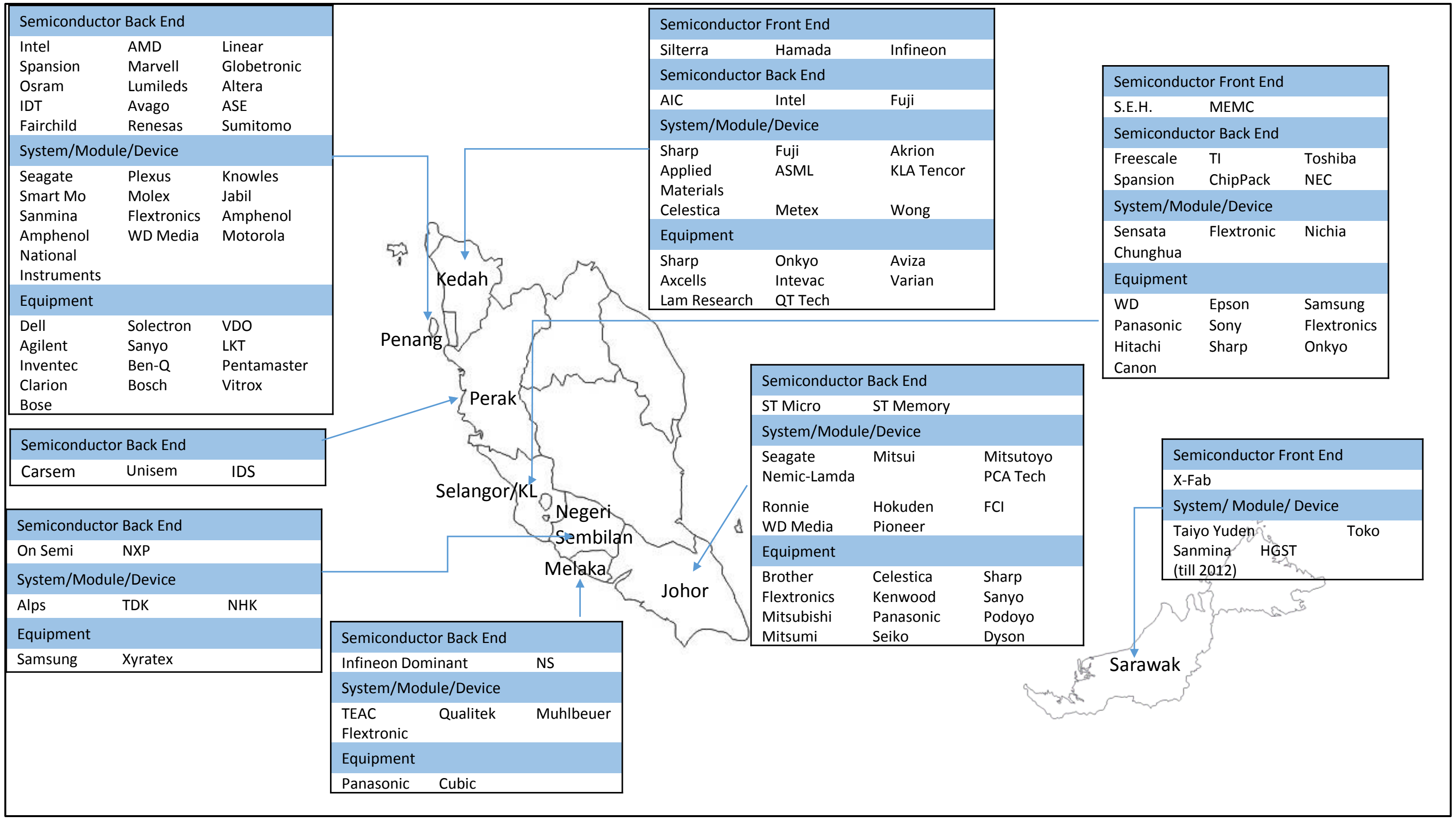
* Since 1990 data have been reclassified into 'electronics' and 'electrical machinery and appliances'. The electronics sub-sector comprises semiconductors and electronic equipment and parts (mainly automatic data processing machines), electrical machinery and appliances refers to consumer electrical products (mainly audio-visual products), industrial and commercial electrical products (mainly telecommunications equipment), electrical industrial machinery and equipment (mainly air-conditioners), and household electrical appliances (mainly rice cookers, washing machines, refrigerators, etc.). Previously electronic equipment and parts were classified under other electrical machinery.

Source: Central Bank of Malaysia, July 2015, Monthly Statistical Bulletin.

Finally, Figure 4.3 below illustrates the E&E industry by geographical region in Malaysia. Penang has the most concentrated E&E firms compared to other states in Malaysia. Apart from Penang, the State of Kedah, Selangor, and Johor have a substantial E&E industry presence. The back-end segment of the semiconductor industry is mainly found in Penang, while wafer fabrication operations are located in Kulim High-Tech Park, Kedah the state adjacent to Penang. The presence of the E&E industry in the state of Sarawak is quite limited, despite having a wafer fabrication operation in Sarawak called X-Fab.[32] Details of IC fabrication front-end players in Malaysia are provided in Appendix 4.5. The states of Johor and Selangor have a bigger mix of electrical industry players, with Dyson in the state of Johor and Panasonic and Sony manufacturing household electrical goods such as TVs and air-conditioners in Selangor.

[32] Previously known as First Silicon, owned by Sarawak State Government, operational in 2001 with capacity of 30,000 wafers per month, 200 mm wafer facility with 0.25um to 0.15um geometries. The Sarawak State Government merged First Silicon plant with X-Fab from Germany in 2007, while retaining undisclosed stakes in renamed X-Fab Sarawak.

Figure 4.3 Map of Malaysia's Major Electronics Companies



Source: Adapted from MIDA in CREST Penang (2013)

Measured by share of value added by state, in 2013 Penang made the highest contribution at 32.5% of total value added in the E&E sector, followed by Selangor at 25.6%, Johor at 14.6%, Negeri Sembilan at 11.1%, Melaka at 4.7%, Kedah at 3.3% and Sarawak at 1.4%. Therefore Penang is the most important state in terms of Malaysia's E&E industry.

4.2.1 The electronics clusters in Penang

As Penang has an important place in Malaysia's electronics industry, this section elaborates on its development path within the industry. According to Athukorala (2012), Penang accounts for approximately 35.0%-38.0% of Malaysia's manufacturing exports,[33] of which E&E has a major share. Penang's electronics industry is mainly dominated by foreign MNCs, with 85.6% of sales value generated by 22.9% of all firms and 72.3% of employment in the manufacturing sector in Penang. Local firms only generate around 14.4% of sales value and 27.7% of all manufacturing jobs in Penang, even though more than two-thirds of the firms in Penang are local.[34] For details see Appendix 4.6 and Appendix 4.7.

Malaysia's electronics industry developed in the early 1970s when eight foreign companies invested in Penang's Free Trade Zone. The original eight companies, some of which have been restructured and renamed, are Advanced Micro Devices Products (AMD), Hewlett Packard (now Agilent Technologies), Clarion, National Semiconductor (now Fairchild Semiconductor), Hitachi Semiconductor (now Renesas), Intel (Malaysia), Litronix (now Osram Opto Semiconductors) and Robert Bosch (Wong, July 2013). With the exception of Fairchild Semiconductor, which has recently

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[33] Based on 1990-2009 period, Athukorala computed the share of Penang in the manufactured exports based on the Socio-Economic Research Institute (SERI), Penang database.

[34] Based on Penang Industrial Survey 2007 by InvestPenang in Athukorala (2012).

announced the sale of its factory near Bayan Lepas, Penang, the rest of the original eight companies remain in Penang. See Appendix 4.8 for a list of the top 25 electronics companies in Penang.

In the 1970s, low labour costs was one of the attractions to the MNCs setting up semiconductor testing and assembly operations in Penang and this electronics cluster thrived, but the industry is mainly confined to IC packaging at the end of the IC production stage.

Later the computer peripheral industry also arrived in Malaysia. The hard disk drive industry started in the late 1980s and early 1990s in Penang (Athukorala, 2012) when more North American and Japanese companies such as Seagate, Maxtor and Hitachi Metals located plants in Penang (McKendrick, Doner and Haggard 2000, Chapter 9 in Athukorala, 2012). This was followed by the printed circuit board (PCB) industry between 1989 and 1991 (Athukorala, 2012), with Singaporean companies such as Solectron (US-owned, later sold to Singapore) also relocating. The arrival of the hard disk drive industry created backward linkages with Malaysian-owned SMEs to serve the demand for high-precision parts for the production of hard disk drives. One such company is Eng Teknologi, founded in 1974 as a hardware electrical shop, which expanded its capacity to cater for high precision components for semiconductor companies in 1979 and ventured into producing hard disk drive actuators in 1988.[35] Today EngTek Group is a multinational itself, with plants in Thailand and China, and in 2007 the group's revenue surpassed RM500 million (US$145.5 million).[36]

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[35] An actuator is an electronic device controlled by a motor that moves the hard drive head arm (Computer Hope, 2015).
[36] US$1=RM3.4376 based on the average exchange rates provided by Central Bank of Malaysia for 2007.

According to Rasiah (2009), external factors in the 1980s such as the appreciation of the Japanese Yen as a result of the Plaza Accord in 1985 encouraged FDI flows to Malaysia's electronics sector. Malaysia and other Southeast Asian countries including Thailand and Singapore benefited from the relocation of production capacity by Japanese firms to Southeast Asia to protect their exports competitiveness because of the high Yen. Internally, Malaysia had already developed some key firms and a trained workforce in the semiconductor industry since the 1970s to cater for the inflow of investment in the late 1980s and early 1990s to other form of electronics such as computer peripherals industry.

By the 1990s there was a labour shortage in Malaysia, with the supply of labour unable to cope with the demand from the manufacturing sector, and the expansion of the E&E industry began to slow towards the end of the 1990s. By the 2000s Malaysia had started to feel the pinch from China, with more MNCs located in Malaysia moving to China and MNCs generally preferring China over Malaysia as an FDI location.

By the early decade 2000s simple assembly operations such as PCBs were among the firms leaving Malaysia. Malaysia responded by starting to bring in solar module manufacturers and LED lighting-related industry into the country. At around this time newspaper headlines reported that firms were moving to China or Vietnam from Malaysia, and with each firm that left, manufacturing jobs were lost, as explored in Chapter 8.

Realising that the missing linkages within the domestic E&E value chain, the Malaysian government sets up a front-end player called Silterra to complete the linkage within the semiconductor industry, which until then had concentrated on back-end operations for MNCs. Silterra is a state-owned wafer fabrication facility located in Kulim Hi-Tech Park, Kedah state and it started production in 2000. Silterra specialised in producing display chips embedded in mobile devices and exported to the US, Taiwan and China (Leong, 7 Jun 2014). However, it has accumulated losses of RM1.7 billion since 2011 and was almost sold off to a Chinese buyer in 2014 (Bloomberg Business, 2014).

The Malaysian government undertook to improve public research institutions' ability to support upgrading in the E&E value chain and in 1985 The Malaysian Institute of Microelectronics Malaysia (MIMOS) was setup under the Ministry of Science Technology and Innovation (MOSTI) to spearhead Research and Development (R&D) to help Malaysia to move up the electronics industry value chain. MIMOS was supposed to function like Taiwan's Industrial Technology Research Institute (ITRI) of Taiwan, which created two major spin-off companies, the Taiwan Semiconductor Manufacturing Company (TSMC) and the United Microelectronics Corporation (UMC). TSMC and UMC are now top world players in IC foundries.

In 1996 the Malaysian government launched the Multimedia Super Corridor (MSC) and provided generous incentives for companies that participated in this initiative. The idea was to emulate Silicon Valley in California as a launch pad for Malaysia to develop Information Technology hardware and software. The Malaysian government also created a high-level scientific advisory body called Malaysian Industry Government for High Technology (MiGHT) in 1993 to gather input from the scientific community for Malaysia's industrial policies.

However, Rasiah (2011) describes these public sector efforts as suffering from a lack of coordination among agencies and deficiency in performance standards, this affected the agencies' ability to help Malaysia's E&E industry move up the value chain. Rasiah (2011) further cites Mohamad Ariff (1991) and Rasiah (1995) comments that ethnic preference policies contradict the industrial policy framework and this constrains the upgrading capacity of Malaysia's E&E industry.

In conclusion, although commendable for its initial success, Malaysia's path to E&E industry development is also ironic. The irony is summed up by the Chairman of Malaysian-American Electronics Industry, Wong (July 2013) a veteran of Intel Penang, who concluded 'Even though Malaysia has had more than 40 years of experience in the E&E industry, we have missed building the ecosystem for the semiconductor sector' (Wong, July 2013, p. 9.). The IC industry can be divided into IC design, IC manufacturing and IC assembly and packaging segment. Malaysia has had a long presence in assembly and packaging, limited involvement in IC manufacturing, but IC design in very much in its infancy. Despite this setback in Penang there are other benefits of FDI-led development, especially once the backward linkages are considered. The details of the backward linkages are explored in Chapter 7.

Going forward, Malaysia needs to build its own brands of electronics products in the international market, which are lacking despite the country's being decades in the electronics industry. Malaysia also needs to reduce its dependence on the FDI model to reduce dependency on foreign technology, uncertainty when FDI relocates away from Malaysia. The FDI model has been very effective in creating jobs when Malaysia, and especially Penang in the early 1970s, was reeling from high unemployment (15% against the national 9%) when the status as a free port was revoked.

4.2.2 Electrical Industry

While the success of the establishment of the E&E industry in the Free Industrial Zone in Penang is well researched (see Athukorala (2012), Grunsven (2006), White (2012) the spread of production networks from Japan into places such as Shah Alam in Selangor (adjacent to Kuala Lumpur) is less well known. Matsushita Electrical Company, later renamed Panasonic, had already set up dry cell battery factory in 1967, followed by TV and refrigerator manufacturing facilities in Shah Alam four years before National Semiconductor invested in Bayan Lepas, Penang.

The electrical product segment of this thesis is confined to household electrical goods such as televisions, washing machines, radios, and microwave ovens. The industry refers to items within this group of products either as 'brown goods' or 'white goods'. The terms came from the main colour of their outer casing. In the 1960s and 1970s, the ovens and washing machines normally came with a white enamel paint casing and thus the term 'white goods' was given. In contrast, the televisions and radios were often encased in wood panels or wood-like materials, leading to the name 'brown goods' (interviewee 2). A more precise definition is given in Chapter 5 and 6 based on groups of trade product codes for the E&E industry as a whole.

Japanese companies in Malaysia dominate the manufacturing of electrical products with brand names such as Sharp, Panasonic, Sony and Sanyo. These companies set up plants in Malaysia mainly for exports, but a minority share of the goods is also sold in Malaysia. In this section I combine works by economic geographers, notably Edgington and Hayter

(2013) with retail market reports and interview data to describe the evolution of the electrical industry in Malaysia.[37]

In the 1980s and early 1990s Japanese electrical retail goods displaced many European brands such as Elba, Zanussi and Electrolux in the local Malaysian market. However, the Japanese brands later faced fierce competition from the Korean LG and Samsung brands and finally lost their market leadership in the audiovisual industry (brown goods) in the 2000s.[38] Although they lost their market leader status Japanese brands maintain a substantial share of the domestic market for audio-visual products. Panasonic retains its market leader status in the white goods category in Malaysia. Malaysian companies' market share remains negligible in white and brown goods except for small electrical appliances, with Pensonic no. 3 in terms of market share (at 12.6% in 2012), just a step behind the European brand Phillips (at 14.0% in 2013).[39] In the late 2000s Chinese brands such as Haier and Midea started to make their presence felt in Malaysia's electrical sector.

To give an idea of the size of these companies, Panasonic Malaysia had a revenue of US$571.26 million (RM1.8 billion) in the 2013 financial year (Lim, 19 July 2013), while that of the biggest Malaysian-owned electrical brand Pensonic was RM 351.43 million (US$111.53 million) [40] (Pensonic Malaysia Bhd, 2014).[41] The Malaysian-owned players started as trading companies in the 1970s and 1980s before venturing into manufacturing their own products. Some companies such as Milux and Pensonic offer

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[37] Retail market reports are Euromonitor International (April 2003) and Euromonitor International (February 2014).
[38] Audiovisual product examples are TVs, video/DVD players, and audio players such as radios, cd players.
[39] Examples of small electrical appliances are blenders and rice cookers.
[40] Converted US$1=RM3.1509 using Malaysian Central Bank average annual exchange rates.
[41] Panasonic Malaysia refers to the group of companies. The revenue of the manufacturing arm, Panasonic Manufacturing Malaysia was RM864.7 million in 2013.

non-electrical households item as well such as household water filters and gas stoves. A list of major Malaysian electrical players is available in Appendix 4.9.

The development of Malaysia's electrical industry was closely intertwined with Japanese FDI in the 1980s and 1990s, and to a lesser extent to the arrival of Korean Samsung electronics at the beginning from 2000s. Edgington and Hayter (2013) summarise the development of Japanese FDI in Malaysia in five stages as shown in Table 4.8:

Table 4.8 Stages of Development of Japanese FDI in Malaysia

Stages (Year)	Description of Japanese FDI in Malaysia
First stage (1960-1985)	Initial growth in factory development, with low-wage labour. The industry grows rapidly and some local linkages with supply companies grow.
Second stage (1986-1995)	The beginning of factory automation in Japanese factories in Malaysia, more hiring of design engineers. Some MNC branches in Malaysia gain Regional Headquarters (RHQ) and logistics functions
Third stage (1996-2001)	Crisis era with reduction in workforce by the Japanese MNCs
Fourth stage (2001-2005)	The number of new Japanese factories being built in Malaysia declines and some Japanese companies exit Malaysia.
Fifth stage (2006-2010)	The firms upgrade existing plants to manufacture higher-end products and some plants gain R&D responsibility. Sharp gains R&D function in Shah Alam, Selangor in 2009 (MIDA Malaysia, 2015). [42]

Source: Adapted from Edgington and Hayter (2012)

Some Japanese subsidiaries in Malaysia have added other functions beyond production after 2000. Sharp established its RHQ in Shah Alam, Selangor in 2000 although Edgington and Hayter (2012) believe that most

[42] For example, manufacture air-conditioned with more advanced features such as energy-saving type, or higher specification such as 3 horse-power (hp) air-conditioned rather than the common 1hp air-conditioned.

Japanese branch firms in Malaysia gained logistics functions for the Southeast Asian region much earlier. Post 2010, Japanese FDI in electrical goods continues to exit with Panasonic announcing the closure of its TV plant in Shah Alam and JVC shutting down its Shah Alam video camcorder factory in 2015. A final point is that most Japanese plants in Malaysia are still reliant on Japan for important parts.

Panasonic (formerly Matsushita) is important as a manufacturer, with air-conditioning, TV and kitchen appliances manufactured in Malaysia. In Malaysia's retail market for electrical products Panasonic is the most important company in white goods followed by Toshiba, Sharp and Sony.[43] In the audio-visual industry, South Korean companies such as Samsung and LG edged past the Japanese in the early 2000s. While LG products are imported into Malaysia, certain Samsung TV models are made at the Negeri Sembilan plant in Malaysia, (Asia Monitor Resource Centre, 2014) and in Shenzhen, China. (Samsung SDI, 2015).

As Malaysia's electrical industry is dominated by foreign MNCs, in 1997 the Malaysian government, under the premiership of Mahathir Mohamad, risked the idea of creating a Malaysia-owned household brand of electrical products to substitute for Malaysian purchases of foreign brands, and eventually to penetrate the international market. The Malaysia Electrical Corporation (MEC) project is a failed experiment and it serves as an important cautionary lesson about the direct state ownership of a company supposed to spearhead Malaysia's foray into electrical industry. Box 4.1 below elaborates on the development of the MEC.

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[43] White goods here cover both major appliances and small appliances. Major appliances in white goods are washing machines, hob ovens, while minor appliances are such as kitchen blenders, shavers, and juicers.

Box 4.1 A State Experiment: Malaysia Electrical Corporation

Malaysia Electrical Corporation (MEC) was launched in 1997 with an ambitious plan to develop a Malaysian equivalent of Japanese conglomerates such as Matsushita/Panasonic for the household electrical goods. The equity ownership of MEC in 1997, estimated at US$266.61 million (RM750 million), is divided among Kuala Lumpur Industries Holdings (60%), a Malaysian state-owned sovereign fund Khazanah Nasional (30%) and Pahang State Government (10%). MEC was given land in Gambang Pahang and financial incentives. The plan was to grow it into a conglomerate to help to replace imports and products manufactured under foreign brands in Malaysia, with a long-term plan of exporting to the international market.

The then Prime Minister of Malaysia, Mahathir Mohamad revealed that MEC would have a huge R&D department to drive its development on 1,200 acres land dubbed MEC City in Gambang Pahang. Mahathir Mohamad argued that while the MEC project involved its own risks the Malaysian government would go ahead with it, as not doing anything would be untenable (Mahathir Mohamad, 1997). Apart from being given state support in the form of land, the project is also located close to a planned highway and next to the University of Malaysia Pahang, to give it a research advantage over its competitors. Pahang state government was given a 10% stake of MEC in return. This ownership of a key conglomerate by the state government in which it operates is similar to the 20% stake of Volkswagen AG owned by the government of Lower Saxony in Germany. Despite the country's ethnic preference policy, the sales and marketing arm of MEC has an ethnic Chinese as the pioneer Chief Executive Officer, which is unusual for Malaysia.

This project mimics its cousin in the automotive industry, Proton City, which itself was modelled on Japan's Toyota City, but this where the similarities between

Proton and MEC end. In fact MEC stood at the other end of the development spectrum. It was not granted tariff protection.[44] The project matches Baldwin (1969, p. 304) prescription of not granting tariff protection to infant industries, but instead 'what is needed is a direct subsidy of knowledge acquisition', as reflected in the R&D allocation for MEC. MEC even invented a time-programmable rice cooker in 1998 (Utusan Malaysia, 1998). Despite this invention, the MEC did not survive the competition from products imported from Japan, China and South Korea or local-made products by other, private companies.

Despite the state support and the unorthodox approach of appointing a non-*Bumiputra* CEO, the project failed and finally went into receivership and was taken over by a state asset restructuring company, Danaharta, in 1999, which finally sold off the MEC.[45] The MEC's marketing arm was sold to Fiamma Group in 2004. While the MEC brand still exists in Malaysia its market share in the domestic retail market is negligible and many Malaysians today have never heard of MEC.

Source: Own Elaboration based on multiple sources

While Malaysia's experiment of direct state-ownership of MEC in the electrical sector has been a failure, private companies such as Malaysian-owned Pensonic Malaysia, Khind and Milux, although commanding a relatively small market share, operate on a more sustainable basis. The most important lesson for industry policy based Malaysia's experience is direct state ownership in corporations to spearhead domestic industrial development such as the MEC case has failed to develop the local household electrical industry.[46]

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[44] While import tariffs for electrical items are officially not yet zero in 1997, tariff protection for electrical items are relatively minimal compared to the national car project, automobile tariff can range from 150%-300% depending on models.

[45] *Bumiputra*: literal translation, "son of the soil", refers to the indigenous segment of the population in Malaysia.

[46] The direct ownership of firms in the case of China works. Hisense is a household name and has had a sizeable presence in Malaysia's TV and refrigerator markets since the 2010s, is owned by the Chinese government. Therefore, there is no hard and fast rule on how to develop an industry.

The household electrical sector in Malaysia remains very much dominated by foreign brands, whether they are manufactured in Malaysia or not, except for small electrical appliances with which Malaysian companies such as Pensonic, Khind, Alpha and Joven is having some success. Pensonic is also expanding regionally into ASEAN markets. On the public sector side, the Malaysian government did well in the first phase of encouraging foreign investment especially Japanese FDI, into Malaysia to manufacture electrical goods in the 1970s and 1980s. However, when the government moved into direct ownership mode in the 1990s as part of a brand building attempt and reduce its foreign dependence for the manufacturing of electrical goods the project failed. Malaysia's final hope of achieving a breakthrough in electrical goods now rests with private companies, but progress is slow. Moreover, household electrical products are finished goods and competition from China for this sector would be fierce, as explained later in Chapters 5 and 6.

4.2.3 Conclusion Regarding Electronics and Electrical Industry in Malaysia

Malaysia's E&E sector developed with FDI-friendly policies such as dedicated free industrial zones since the 1970s attracted MNCs from North America and Japan to set up factories in Penang and marked the first phase of the development of the electronic industry with success. Similarly, FDI-friendly policies also attracted the setting up of the electrical industry in free industrial zones in other states such as Selangor and later Negeri Sembilan and Johor, with Japanese FDI having a strong presence in Selangor's electrical appliances industry.

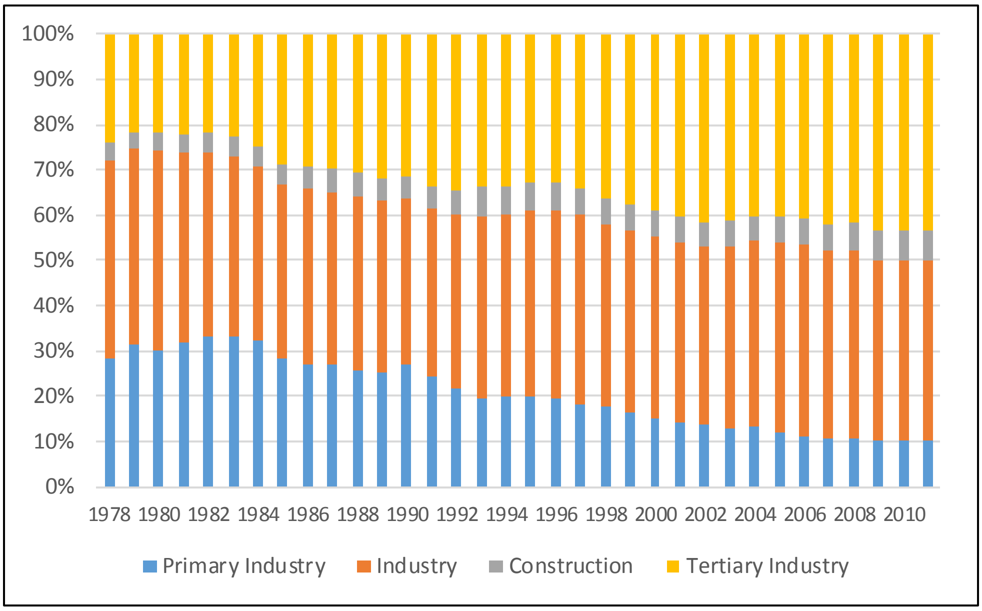
While Malaysia was successful in attracting FDI in the first phase of the development of E&E industry in the 1970s and 1980s, the upgrading of its E&E value chain remains an uphill task, especially since Malaysia is still dependent on foreign MNCs in the semiconductor industry. Its efforts to upgrade the backward linkages in semiconductor machinery are discussed in Chapter 7. Foreign brands still dominate the electrical goods sector. The dominance of Japanese MNCs in electrical goods in Malaysia was affected by the imports of electrical items from Korea in the late 1990s. This, coupled with the influx of Chinese imports, especially in the late 2000s, has eroded the Japanese firms' market leader positions for domestic retail market of electrical goods in Malaysia. This is discussed in Chapter 5 under the Import penetration results section.

In the electrical sector, the state experiment with MEC failed and MEC were sold off in 2004. The MEC case informs the development strategies literature that for a smaller country such as Malaysia with a relatively small population, direct ownership of the state enterprise is not the best choice as a path-breaking development tool. Instead, privately held Malaysian companies are sustainable in the long run, though with more limited success compared to foreign brands. As a finished goods sector, the prospects of fierce competition from China present a great challenge.

4.3 Evolution of the Chinese E&E industry

The macro-level structure of China's economy has changed, with the contribution of *Primary Industry* in GDP falling while the share of *Industry* increases over 1978-2011. Figure 4.4 below shows that the manufacturing sector, a subcategory under *Industry* including *mining and quarrying, manufacturing, production and supply of electricity, water and gas* (National Bureau of Statistics of China, 2015), has been resilient throughout the entire period, with average 40.3% contribution to GDP.

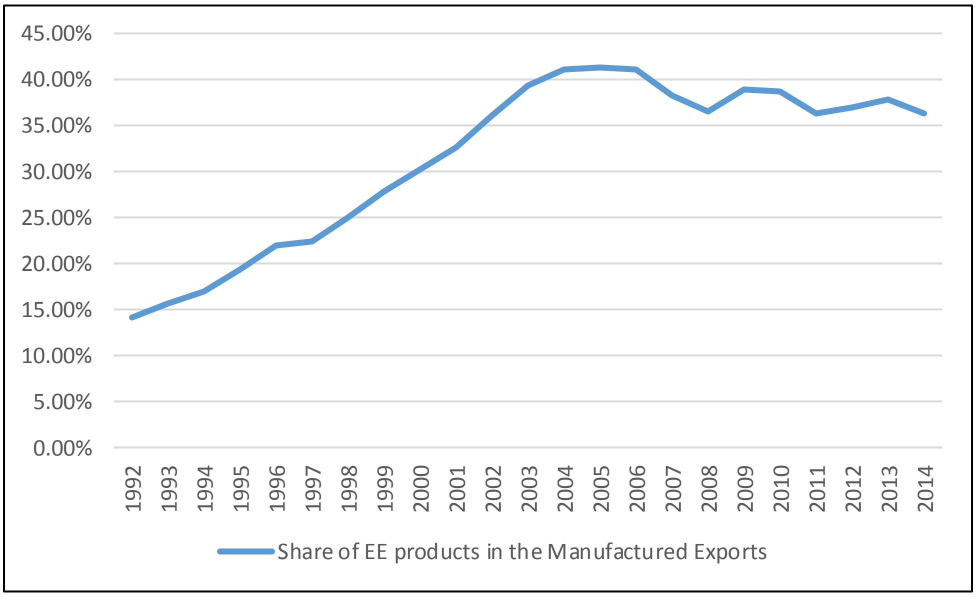
Figure 4.4 China GDP by Activity (% of GDP)



Source: Data from National Bureau of Statistics China

China began to develop today's success in its E&E industry in the early 1980s when it opened its door to the world through its special economic zone (SEZ) in Shenzhen City in Southern China in 1979. The success of the SEZ in Shenzhen was then replicated in 14 other coastal cities, which among others include Shanghai (Fu and Gao, 2007), with multiple exports processing zones (EPZ) in each SEZ. China's E&E industry then developed rapidly, and the share of E&E in China's total manufactured exports rose from 14.1% in 1992 to a peak of 41.4% in 2005 before descending slowly to 37.9% in 2013, as shown in Figure 4.5 below.

Figure 4.5 China: E&E as Share of Total Manufactured Exports



Source: Based on UNComtrade data

Although China started by offering an EPZ similar to Malaysia's FIZ zone in China's initial phase of development, it did not follow the FDI model in entirely the same way as Malaysia or Singapore in developing its electronics industry. China had a different strategy, and started to import production lines from Japan to learn about the industry in the 1980s and early 1990s. Clearly, China has import substitutions aims by developing its own industry by importing the production lines, while simultaneously encouraging FDI from foreign sources. For example, other than purchasing TV production lines from overseas, China also acquired technology through a licensing arrangement with Panasonic of Japan to build plants in China manufacturing TVs as a joint-venture mode in 1987 (Panasonic Corporation, 2015).[47]

China's industrial policy gave high priority to the semiconductor and electronics industry. China created a superstructure called the Ministry of Information Industries (MII) in March 1998 to develop its electronics industry by merging the Ministry of Post and Telecommunications with the Ministry of Electronics and Information (Pecht, 2006). The Ministry of Post and Telecommunications was responsible for telecommunications standards and access and the Ministry of Electronics and Information was responsible for developing computer hardware and software. The merger ensured that the regulatory environment supports and does not impede the growth of China's hardware and software industry.

In addition, China funds the development of its own IC industry to wean it from dependence on foreign semiconductor companies for IC chips. In June 2014, MII and the National Development and Reform Commission of China announced an approximately US$100 billion fund (Davis, 2015) under the National Guidelines for Development and Promotion of the IC Industry for the next ten years supporting various initiatives to develop the semiconductor industry in China.[48] Initial funding of RMB120 billion (approximately US$20 billion) is already secured for spending between 2014 and 2017. The fund stakeholders include national and municipal governments and private equity players.

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[47] However, Panasonic announced they would exit TV manufacturing in China by closing down a factory in Shanghai, and make its facilities in Shandong the main producer of LCD TV in 2015.

[48] Various figures have been quoted on the online news portal. The Bloomberg report quoting a RMB 1 trillion or US$161 billion Semiconductor Industry Development Fund to develop Chinese semiconductor industry over the next 10 years is at the high end of the figures (King, 2015) whatever the figure is, it is certainly huge even by semiconductor industry standards.

Among the stated goals of the national guidelines are closing the technology gap between China domestic IC firms and international players by 2020, China's semiconductor fund is mainly targeted at IC manufacturing within the IC industry, with 60% of the US$100 billion to be spent on the manufacturing segment. Although China already has some achievements in the IC design segment, its manufacturing technology still lags behind that of Taiwanese firms.

The large size of China's semiconductor fund surprised the global semiconductor industry. As a comparison, it currently costs about US$5 billion to build a state-of-art wafer fabrication plant. China has US$6.67 billion per year under the fund and therefore can add a state-of-art wafer plant every year with some money to spare. At this rate, China will change the international semiconductor industry landscape.

China is successful in creating brand names and building sizeable players in the semiconductor industry that are able to compete internationally, such as HiSilicon and Semiconductor Manufacturing International Corporation (SMIC). This success is also replicated with developing overseas sales channels for its final goods such as computer industry. Its Legend Computer, renamed Lenovo in 2001, acquired IBM's personal computer line of business in 2004 and is currently the top PC maker in the world by value of shipment.

One of China's strategies for development, although not officially acknowledged is informally known as 'shanzai'. Box 4.2 elaborates further on shanzai as a development strategy.

Box 4.2 Shanzai: an informal strategy of development in China

China has come a long way in developing its electronics industry since it was a shanzai model. The word 'shanzai' literally means fortress. Foreigners believe this refers to the cluster of companies that copied and produced mobile phones but sold them at rock bottom prices. For example, a week prior to the launch of the iPhone 6s in September 2015, models physically identical to the iPhone 6s but based on the android operating system were already on sale in stores in Shenzhen, China (Lee, 2015). Some thirty stores bearing an Apple logo were taking orders for iPhone 6s even though Apple only had one store and five authorised dealers in Shenzhen, China. (Lee, 2015) However, this strategy is not confined to E&E: Chinese companies are also known to have copied automotive models based on Toyota and Land Rover. But beyond the literal translation of shanzai as fortress, the word connotes a highwayman lair (interviewee 3). This shanzai concept transcends the usual understanding of simply copying of the latest products to include the brutality of the market. Competition in terms of pricing in China is not only stiff, it is cut-throat. To survive in this harsh environment Chinese players may make temporary alliances of convenience but fight for market share when their strategy requires them to.

From originally referring to companies that shanzai (copy) phones, China has built successful companies that have survived the brutal competition with some brands such as Xiaomi recently recruit an ex-Google Android executive to help to build its international market.

Shanzai as an informal development strategy has its own limitations. For a start, foreign MNCs, wary of their Intellectual Property (IP) being copied in China, might not want to locate a state-of-the-art facility in China, slowing the pace of technology transfer from foreign players to China. Secondly, from China's point of view, extreme competition means that profit margins become so thin that beyond a certain point there is no way to support quality aftersales service, and brand-building becomes difficult in a disorderly market. In China big brands such as Lenovo computers and Hi-sense TVs have to constantly battle grey-market players selling breakdown or semi-breakdown units in China that can assembled at a fraction of the official retail price. Going back to the iPhone 6s, the price of an Android-based shanzai iPhone 6s is between RMB580 (US$91) and RMB 630 (US$99) retailing in the mega retail avenue dubbed as 'electronics city' of

Huaqiangbei in Shenzhen. On the other hand, at the online Apple Store in China (http://www.apple.com/cn/shop/buy-iphone/iphone6s, accessed September 28, 2015) the iPhone 6s retailed for RMB 5,288 and the iPhone 6s Plus for RMB 6,288. (Lee, 2015)

Source: Interview data and secondary sources

4.3.1 Electronics: The semiconductor industry

This section discusses the evolution of China's electronics industry based on the semiconductor industry. The semiconductor industry consists of ICs and discrete devices. The section begins with a brief history of China's semiconductor history before going into the current position of its semiconductors in the world market. Three segments of the IC industry in China – IC design, manufacturing, and test and assembly – are discussed. The conclusion is that China will move forward in the semiconductor industry, despite the challenges.

China's electronics industry began to develop rapidly in the early 1980s with its Open Door policy. From the beginning, China aimed to be independent in its consumption of ICs. Specifically, China's company called Hua Jing acquired 3-inch wafer technology from Toshiba in 1982 (Pecht, 2006).

In the 1990s, China's semiconductor industry development strategy included encouraging the transfer of technology through FDI. In 1995, it launched the Pudong Microelectronics Centre in the Pudong New Area of Shanghai to encourage domestic production of IC and reduce reliance on IC imports, which were increasing as more electronic and electrical items were being assembled in China. Under Project 908,[49] Huajing further set up a 6-inch wafer productions line with technology from Lucent.[50] It also sought help from companies such as Motorola, NEC, Mitsubishi, STMicroelectronics, Phillips, Siemens and Toshiba in building its IC industry (Pecht, 2006). Later in the decade, NEC established joint ventures with a Chinese partner, Hua Hong-NEC, under Project 909 for two wafer fabrication plants to produce Dynamic random-access memory (DRAM) IC for export back to Japan (Pecht, 2006). [51]

In the decade 2000-2010, China continued to seek foreign technology to develop its semiconductor industry. During this time, Taiwanese companies such as TSMC and UMC invested in manufacturing ICs in China. Intel also invested in assembly and testing at Shanghai in 2003, followed by an R&D centre, also in Shanghai, a year later.

The case of Motorola's exit from the wafer fabrication business in 2003 exemplifies the transfer of technology from foreign firms to China (Pecht, 2006). Motorola build a fabrication facility in Tianjin city in 1995 with plans to double its size in 1998 with cumulative investment of US$3.4 billion. In 2003 it sold the wafer fabrication business to a contract manufacturer, SMIC. SMIC was founded in 2000 by a Taiwanese-American Richard Chang, who was recruited by the People's Republic of China's Government to help them to bring its semiconductor foundry industry to the next level. It helped China to launch its first 300 mm wafer fabrication plant with 0.11 to 0.10 µm process technology in 2004, marking China's entry into the IC industry at a very sophisticated level. SMIC is headquartered in Shanghai

[49] National Project 908 and National Project 909 are projects launched by the State Council and the Ministry of Electronics Industry in Beijing.
[50] In IC industry, 6-inch refers to the silicon wafer size that is used in fabrication process, the bigger the wafer, requires higher technology development costs but offers lower unit costs in the long run.
[51] DRAM is the IC chips that hold the data that is needed to be accessed by the Central Processing Unit (CPU) of the computer quickly, the DRAM is dynamic memory because it is volatile and once power is cut-off, the memory held by DRAM is lost. (The PC Guide, 2001)

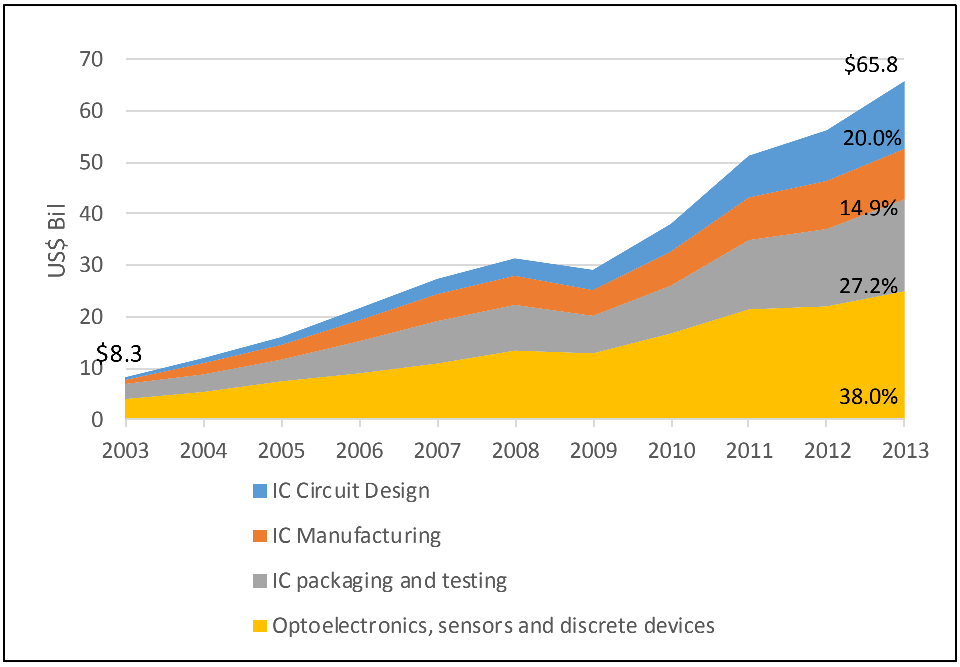
and is one of the top semiconductor companies in China by revenue. It is state-owned, although its stock is listed on both the Hong Kong and the Shanghai stock exchange.[52] China's strategy for development includes acquiring foreign technology when required, as in the case of Motorola exit from China. This exit from China is part of Motorola's global business and part of it involves spins off its IC fabrication business as Freescale Semiconductor in 2004.

Despite SMIC's achievements, Taiwanese foundries still lead in manufacturing process technology. As a comparison, TSMC of Taiwan has wafer plants for 300 mm wafers for 0.13 µm to 90 nm, 65 nm, 40 nm and 28 nm process technologies. TSMC also has R&D under way to churn out 450mm wafers for cutting edge 10 nm process technologies (Lisa Wang, 2012) compared to SMIC's processing technology capacity of 0.35 µm to 28 nm.[53]

Figure 4.6 China's Semiconductor Industry by Sector, 2003-2013

[52] The biggest shareholder of SMIC is the investment arm of the Shanghai Municipal Council. (Chu, M.-C. M., 2013)

[53] For semiconductor productions, the lower the figure, the better and more powerful processor is produced as more transistors can be fitted into a processor of the same area. The figures are referring to the area between the 'field-gates' of the transistors implanted within the processor.



Source: PricewaterhouseCoopers (January 2015, pp. 23.)

Referring to Figure 4.6 above, the share of revenue based on the semiconductor industry segment reflects the structural changes in the IC industry. Total revenue in the China semiconductor industry grew on average by 23.0% per year from US$8.3 billion in 2003 to US$65.8 billion by 2013. The IC design segment's share of total revenue in the semiconductor industry rose from 6.5% in 2003 to 20.0% in 2013, and IC manufacturing from 9.1% in 2003 to 14.9% in 2013. Shares of total revenue in the semiconductor industry in the IC packaging and testing and optoelectronics, sensors and discrete devices segment fell from 2003 to 2013. China's increased share in semiconductor design and the manufacturing segment, both of which are more skills-intense and require complex production facilities, shows that it has developed its capability over the last ten years.

The design segment is the strength of China's semiconductor industry. In 1990 China had only 15 design enterprises in this segment, and this grew to 463 in 2003 and to 583 by 2013. Secondly, China has created economies of scale to help the domestic semiconductor company to thrive. In 2011, China achieved another milestone with its first RMB1-billion-revenue domestic semiconductor company, HiSilicon Technologies. HiSilicon Technologies is a fabless, or design-based semiconductor player, and most of the top semiconductor companies in China are in the design segment, as shown in Table 4.9 below.

Table 4.9 Top 10 Chinese Semiconductor Company in China

	Segment	Rank		Sales Revenue (US$ Mil)		
Company		2012	2013	2012	2013	Change (%)
HiSilicon Technologies	Design	1	1	1,178	2,120	80.0
Spreadtrum Comm.	Design	2	2	696	1,013	45.6
RDA Microelectronics	Design	3	3	392	455	16.2
Datang Semiconductor Design	Design		4	300	390	29.9
Beijing Nari Smart Chip Microelectronics	Design		5		350	
Sanan Optoelectronics	Discrete	5	6	260	348	33.7
No. 55 Research Inst. of China Electronics Tech.	IDM	4	7	313	326	4.3
MLS Co. Ltd.	Discrete	16	8	149	319	113.6
Hangzhou Silan Microelectronics	Design	6	9	201	293	45.9
Galaxycore Inc.	Design	7	10	187	273	45.8

Note: PricewaterhouseCoopers (PWC) ranked, based on 'indigenous' company. SMIC is ranked 3rd largest manufacturer by revenue in 2013 by PWC, but is not technically indigenous as it is listed on both the Hong Kong and the New York stock exchange.

Source: PricewaterhouseCoopers (January 2015, pp. 36.)

China has increased the capacity and technology level of its IC manufacturing segment. It had 15 foundries in 1990; by 2003, this had grown to 56 and by 2013, to 160, and their capacity grew from 5.7% of world capacity in 2003 to 10.9%, or 2.3 million 8-inch-equivalent wafers per month in 2013 (PricewaterhouseCoopers, January 2015).[54] The top five major foundries in ranked capacity are S.K. Hynix (13% of China's total capacity), SMIC (13%), Hua Hong Grace (6%), Intel (5%) and TSMC (5%) (PricewaterhouseCoopers, January 2015). However, in the manufacturing segment capacity is not the only measure, with processing technology in

[54] An 8-inch wafer is equivalent to 200mm wafers.

nanometres (nm) representing closeness to the chip fabrication frontier. TSMC's 20 nm manufacturing process is ahead of SMIC's 28 nm in 2015. In 2010, SMIC's 65 nm process was about 3 generations from the manufacturing process frontier. Part of the constraint in the development of China's IC manufacturing segment lies in export control on the part of the FDI country of origin such as the US, as explained in Chapter 8 (Section 8.3.1).

China's production capacity in the semiconductor packaging and testing segment has increased from 10.5% of world capacity in 2003 to 27.4% in 2013, based on floor space, with an increase from 77 production facilities in 2003 to 116 facilities in 2013 (PricewaterhouseCoopers, January 2015). Most of the largest and most advanced packaging and testing facilities were foreign-owned in 2003 but this changed in 2013, marking a structural shift in this segment. The top 5 players in packaging in China in 2003, representing 22% of China's total capacity, were ASE, followed by Intel, SDI, STATS ChipPAC and Integrated Microelectronics (PricewaterhouseCoopers, January 2015). In 2013, 3 of the top 5 semiconductor packaging companies, listed here in order of capacity, were indigenous Chinese companies: Jiangsu Changjiang Electronics Technology Co., Ltd. (9.5% of China's total capacity), Tanshui Huatian Technology (8.3%), ASE (7.0%), Chipmore (4.7%), and STATS ChipPAC (3.5%). ASE is headquartered in Taiwan, while STATS ChipPAC is a Singapore-based company. (PricewaterhouseCoopers, January 2015)

Despite adding semiconductor IC production capacity for since the 1990s and early 2000s, China's local production of ICs could only supply 30% of demand in the decade 2000-2010s, with the rest imported (Pecht, 2006). China's dependence on imported IC semiconductors continues today. Based on 2013 figures, it now produces 12% of the world's semiconductors but consumes 55.6% of global capacity or US$169.9 billion (RMB 1,111.7

billion) of worldwide consumption of US$305.6 billion (PricewaterhouseCoopers, January 2015), making it the world's biggest consumer of semiconductors.[55] Interestingly, PricewaterhouseCoopers (January 2015, pp. 2.) expected China's production of semiconductors to grow faster than its consumption ten years ago, but it turns out that consumption has outstripped production. At this point it is useful to recall the Asian Drivers literature (IDS, 2006), which discusses China's threat to other developing countries' exports while at the same time creating new demand for goods. Based on the semiconductor segment alone, it seems that the story fits the latter rather than former.

Although China has been more successful in developing its semiconductor design segment, it is still reliant on foreign MNCs for manufacturing technology. The top 10 semiconductor suppliers in China are all foreign companies and account for 42.9% of total revenue earned by all semiconductor producers in China in 2013.[56] However, China has developed some of its manufacturing capability through companies such as SMIC. The top semiconductor suppliers are shown in Table 4.10 below:

Table 4.10 Top 10 Semiconductor Suppliers in China 2012-2013

	Rank		Revenue in US$ Bn			
Company	2012	2013	2012	2013	change	% Market share
Intel	1	1	25.1	24.9	-0.5%	13.8%
Samsung	2	2	11.5	13.7	19.9%	7.6%

[55] China's production figure by revenue actually puts it at 17% of total global production, based on data provided by the China Semiconductor Association, according to PWC. PWC however thinks the figure is influenced by the Integrated Device Manufacturer (IDM) model, where foreign MNC dominates production in China. Therefore PWC re-estimates Chinese production to be around 12% of global semiconductor production. Malaysia on the other hand is a net exporter of IC semiconductors, with consumption estimated by the researcher to be around 3.6% of total world consumption and production close to 5.8% in 2013, based on the world production figure of US$315.4 billion provided by Gartner. (Gartner, 2014).

[56] Suppliers inclusive of all type of players, IC Design, Manufacturing, Assembly and Tests, and IDMs.

SK Hynix	5	3	5.1	7.2	41.5%	4.0%
Toshiba	4	4	5.2	5.9	14.2%	3.3%
TI	3	5	5.4	5.6	3.8%	3.1%
Qualcomm	10	6	3.2	4.7	46.9%	2.6%
ST	6	7	4.4	4.5	4.3%	2.5%
AMD	7	8	4.2	4.1	-4.0%	2.2%
Freescale	8	9	3.6	4.0	11.1%	2.2%
Renesas	9	10	3.3	3.0	-7.7%	1.7%
Total Top 10			70.8	77.6	9.7%	42.9%
Total Top 10 (% of market)			43.0%	42.9%	-0.2%	

Source: CCID, IC Market China 2013 & 2014 Conference -March 2013 & March 2014 in PricewaterhouseCoopers (January 2015, pp.15.)

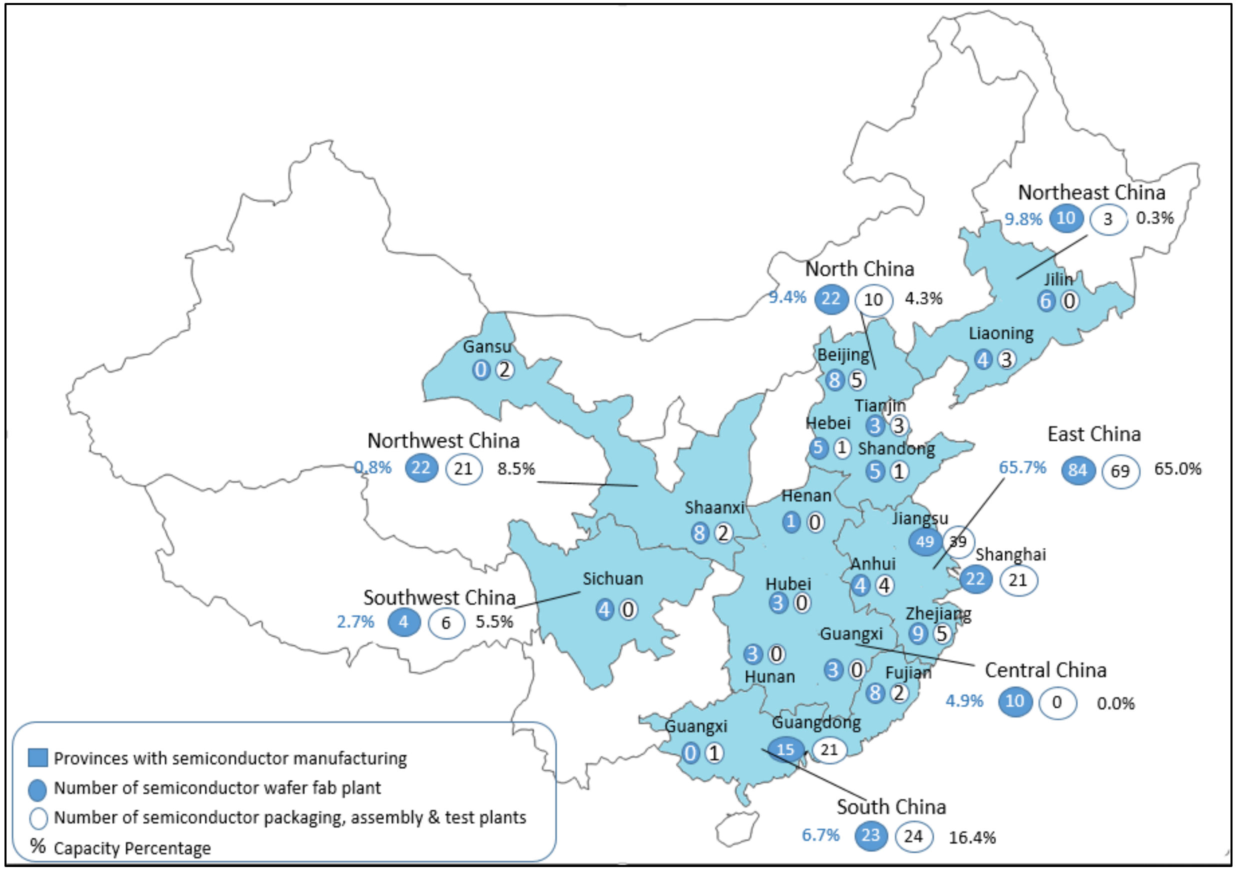
Despite recent progress in building its semiconductor industry, challenges remain: China's industry development is still dependent on government funding and lacks a sustainable business model and a strategy for competing in ways other than pricing (Allen Lu, 2015).

Regionally, the semiconductor industry begins in the coastal area concentrated in the Yangtze River Delta, the Bohai Area and the Pearl River Delta before spreading to the interior of China (most notably in the Sichuan area).[57] Provinces around the Yangtze River Delta such as Jiangsu, Anhui and Zhejiang account for 65.7% of wafer fabrication capacity, followed by Bohai, the region associated with Beijing; Tianjin and Shandong in Northern China with 9.4% of total wafer fabrication capacity; and in the south of China around the Pearl River Delta, 6.7% of wafer fabrication capacity. For test and assembly segment, Guangdong area, which includes the Pearl River Delta has 16.4% of total China's capacity, second only to Yangtze area with 65% of China's total capacity. To illustrate the movement from coastal area into inner China, Intel moved its manufacturing plant westward into Chengdu, in Sichuan province, when labour costs increased in Shanghai,

[57] Yangtze River Delta area is associated with Shanghai area. Bohai area is associated with Shandong, China. Pearl River Delta is associated with Hong Kong and Guangdong Area.

but kept an R&D centre in Shanghai. Figure 4.7 below, shows a detailed map of the semiconductor industry in China.

Figure 4.7 Map of China's Semiconductor Industry



Source: PricewaterhouseCoopers (January 2015, pp. 52.)

China's huge consumption of semiconductors is due to the increasing shift of global production of electronic and electrical products such as mobile phones, tablets and computers into China. The IC demanded from China feeds into the production of final electronic goods and household electrical items. The production of an estimated 35.1% of worldwide electronic equipment is located in China, and this will continue to increase to 38.0% by 2017 according to the Gartner forecast cited in PricewaterhouseCoopers (January 2015). The report (ibid.) estimates the top 10 Original Equipment Manufacturer (OEM) companies such as Huawei, Lenovo, Haier, TCL and Changhong consume about US$55 billion or 30% of total semiconductor consumption in China. Haier, TCL, and Changhong are household electrical brands in China, and are discussed in the next section of the chapter.

In conclusion, China's electronics industry has grown rapidly in terms of both revenue and capacity, especially in the last decade. If we include SMIC in the analysis of the manufacturing segment, China is a step closer to frontier technology with 28nm wafer process technology. Finally, China also faces challenges in the electronics industry such as the fear of lack of IP protection, and the Chinese government strategy of influencing the direction of foreign-owned enterprises in China (Pecht, 2006). These issues can slow the pace of technology transfers as foreign firms are reluctant to locate their cutting edge plants in China. Still, China, with its generous semiconductor fund and dynamic workforce, can only move upwards in the world market for semiconductors.

4.3.2 Electrical Industry

Interestingly, the TV industry in China created demand for ICs, bringing about the rise of the semiconductor industry in China. The Huajing Group, imported the Toshiba production line of IC to manufacture the components that feed into TV production in China (Pecht, 2006). This section discusses China's electrical industry based on the TV segment, briefly touching on parts played by the computer and small appliances segments in the development of the industry.

According to National Bureau of Statistics of China (2014), TV production in China reached 127.7 million units in 2013. Based on IHSGlobal's estimation about 43.5 million TVs are consumed locally, leaving about 65.9% of China's TVs to be exported worldwide. [58] The TV manufacturing business is described as cut-throat domestically, with all six of the top 6 TV makers in China experiencing losses in 2012. (IHSGlobal Technology, 2012). Chinese companies have had to turn to international markets for better profit margins. This is an achievement considering the humble beginnings of Chinese TV manufacturing companies about three decades ago.

According to Pecht (2006), the first TV in China was made in Tianjin in 1958. The present TV industry started in 1979, when Shanghai Gold Star TV factory bought the TV production line from Hitachi of Japan, followed by factories based in Tianjin and Beijing purchase of production line from Toshiba and Panasonic respectively (Pecht, 2006). By 1985, Pecht (2006) reports, Shenzhen-based Konka had imported a 147th line of TV production into China from a Hong Kong company. The major players in the TV industry in China are listed in Table 4.11 below:

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[58] Figures on based on IHSGlobal Technology (2012).

Table 4.11 Major TV manufacturers in China by Capacity in the 1990s

Name of company	Market entry (year)	Reported production capacity (incl. black & white TV)	Ownership
Changhong	1979	12,000,000	State-owned
Konka	1984	7,000,000	Former Hong Kong joint-venture acquired by mainland interest in 1997
Panda	1982	4,000,000	State-owned
TCL	1992	3,600,000	State-owned
Qingdao Hisense	1983	1,300,000	State-owned
Haier	1997	1,000,000	State-owned white goods maker diversified into CTV market by acquisition
West Lake	1982	1,000,000	State-owned
Hitachi	1981	800,000	50%-owned joint venture (Japan)
Sanyo	1992	1,200,000	50%-owned joint venture (Japan)
Skyworth	1990	2,000,000	Private firm, Hong-Kong controlled
Philips	1992	800,000	51%-owned joint venture, Netherlands controlled
Samsung	1994	800,000	50%-owned joint venture (S.Korea)
Sony	1996	3,000,000	70%-owned joint venture (Japan)
Matsushita	1996	500,000	50%-owned joint venture (Japan)
Sharp	1996	1,000,000	70%-owned joint venture (Japan)
Toshiba	1996	1,000,000	70%-owned joint venture (Japan)

Source:White and Linden (2000) and Xie (2001) in Xie and Wu (2003, pp. 1468.)

Xie and Wu (2003) divide the development of China's TV industry into three stages. The first stage is 1980-89, when China's players were exposed to TV imports from Japan which were more sophisticated, far more reliable and had more product offerings. China's TV-makers were in learning mode in 1980-1985 and producing low-quality sets compared to the imports. In 1989-2000, during the deregulation period, China's TV industry started to become competitive. This was because before 1989 the central government set TV prices and therefore there was no cost competition among domestic TV makers. In 1989 Changhong disregarded the government rules by reducing its TV price unilaterally, unleashing the market mechanism, and domestic TV makers started to face cost pressure and had to innovate to survive in the industry.

The Chinese government was pragmatic about the developing industry. In the beginning, tariff protection was given to domestic TV makers and the reduction of import duties was carried out gradually in 1992, 1996, and 1999. This gradual removal of tariff protection was paced with the domestic industry player's development. By 1997, China's domestic players had already increased their share of the domestic market to 81.0% from 15% in 1983 (Shaojia, 2001, pp. 23.). And from 2000 onwards, China's TV manufacturers have continued upgrading the technology and reducing costs, although they are still dependent on foreign firms for key components.

China is currently the biggest exporter of TVs in the world, overtaking the Japanese and the South Koreans. In 2013, China's TV exports were worth US$26.2 billion, 26.1% of the world exports market. This is a major achievement given that twenty years ago China only contributed 4.2% of total world exports in 1993. By 2013 approximately one in four of the TVs on the world exports market were made in China.[59] China continued to accelerate its TV industry development and in 2010, overtook Mexico (20.3% of world's export) as the biggest exporters of televisions in the world with 22.2% of world exports.

China achieved top exporter status while developing its own brands such as Changhong, Hisense, and Haier, which become significant international players by the end 2000s. China's top TV exporters are now brand owners

[59] The figures based in this paragraph are based on UNComtrade, therefore, some of the exports could include Japanese companies based in China exports. However, the discussion that follows will show China has indeed been becoming more dominant and presents great challenges to the Japanese and South Korean TV manufacturers.

and lead firms themselves in the TV market to the extent that China now outsources 40 million TV units, worth about US$4.5 billion, to Taiwanese firms to meet demand (Xinhua, 2012). As further testament to the success of China's firms, in the third quarter of 2014 for the most sophisticated TV market segment to date called Ultra High Definition (HD) TV, Hisense shipped 10% of global Ultra HD TVs, in third place, ahead of Sony (7%) and behind South Korea's Samsung (36%) and LG at 15% of global Ultra HD TVs (Wheatly, 2014). The success of Chinese firms such as Hisense was predicted in the Asian Drivers literature (IDS, 2006), but what is astonishing is the pace: Hisense only entered the TV market in 1983 and is now already one of the top players, not only in China but also globally.

The computer industry began in 1955,[60] but its development started rapidly after the opening up of China from the 1980s onwards. This section will refer to the Lenovo group and its origin, to illustrate China's path developing its computer industry. In 1985 China marked the rebirth of its computer industry with Great Wall 0520CH, the first PC to process information in Chinese (Pecht, 2006). The Great Wall 0520CH was built by the State Computer Industrial Administration and understandably was used by China's government administration offices such as Customs Administration (Pecht, 2006). In 1986-1990 China began to develop the computer industry based on market needs and by 2000 it had taken off with an average of 20% annual growth based on PC shipments from 2000-2005 (Pecht, 2006).

Interestingly, within the span of 30 years from 1982 to 2012, Lenovo, a Beijing-based company founded in 1984, overtook US based Hewlett-Packard (HP) to become the biggest global PC maker by volume in the second quarter of 2012 (Gartner Inc., 2012). Not only did Lenovo leapfrog

[60] China's first computer was codenamed 901, build in 1955 in the University of Harbin, with Soviet Union aid for scientific research (Pecht, 2006).

over Taiwanese giants such as Acer and Asus but it also overtook HP as the world's number one PC supplier. The success of Lenovo was hailed by *The Economist*: 'From guard shack to a global giant', referring to the premises where the founder of Legend Group first started. (The Economist, 2013).

The path of Lenovo's success was not an easy one, from its humble beginnings as part of China's Academy of Sciences in Beijing before the Legend Group, Lenovo's predecessor, was founded in 1984. The Legend group grew out of the strong competition in China's PC market, where PC units are called as 'white boxes', with garage industries buying different PC components and assembling and selling them at a significantly lower price than branded Legend computers. Legend overcame these domestic challenges and changed its name to Lenovo in 2003, targeting overseas markets to overcome the low margins on the domestic market. It made the strategic decision to acquired IBM's personal computing business in 2005. From there it grew very rapidly to achieve its status as the top PC vendor in the world in the third quarter of 2012.

The important lessons on China's path to development here include acquiring brand names and technology at opportune times to kick-start itself into the global competition. This is in stark contrast to the strategy of the FDI-led model in other developing countries that continuously focus on FDI inflows from traditional sources such as the US, Europe and Japan to upgrade their industry structure. China, in contrast, has used outward investment at strategic moments to upgrade its industry and seize the international market, as demonstrated by Lenovo.

The next section discusses the electrical appliances industry as part of China's development in the E&E sector. The electrical retail market, which covers both major electrical appliances such as refrigerators and washing machines and minor appliances such as blenders and dehumidifiers etc., was worth RMB547.5 billion (US$89.04 billion) in China in 2013. [61] As a quick comparison, the consumption of semiconductors in China is worth slightly over three times the retail value of the household electrical industry.

Some players are similar to the TV industry players such as Haier, which is both an audio-visual manufacturer and has diversified into white goods. However, this section discusses another company, China White Goods Co. (CWG – name changed for anonymity). CWG is headquartered in Guangdong Province and started as an OEM company for foreign air-conditioner brands such as Carrier, etc. Learning from the foreign technology, CWG then channelled its surplus production capacity into products such as air-conditioners, washing machines, and kettles that bear its own brand name to become a RMB 92.6 billion (US$15.1 billion) company by revenue in 2013. [62] CWG continues to do OEM for North American brands for exported into advanced markets, but manufactures its own products for domestic markets such as in Guangdong, Anhui and Hubei provinces. It manufactures its own products in Vietnam and markets its own brand name in developing countries such as Vietnam and India. CWG entered Malaysia's market in 2003 through a Joint-Venture (JV) with a Malaysian companies, DRB-Hicom.

China's success in the E&E industry is not confined to acting as a production base for MNCs: it has developed its own international brand names. It is not possible to capture all aspects of its success as a relatively latecomer in the industry that grew to become market leader, so this section focuses on certain cases such as Lenovo. Other upcoming brand names include Beijing-based Xiaomi, which surprised the Asian mobile

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[61] Figures are based on Euromonitor International (March 2014).
[62] RMB converted using US$1= RMB6.1488

phone market in 2013 and posed a serious challenge to Samsung of Korea in the Asian mobile phone market.

This section on China's development of electrical goods has shown the China's development choices and policies, illustrated with some specific goods such as TV, and companies such as Lenovo in the computer industry and CWG in the household electrical industry. The TV industry developed with timely use of policy tools such as staggered tariff reductions, and in the case of Lenovo China penetrated the international market by acquiring the IBM's PC unit, while CWG, based in Guangdong Province, started with OEM strategy, learning new technology from foreign companies before itself growing into a big global player in white goods.

4.4 Conclusion

Malaysia and China have followed different paths in developing their E&E industry. Given the relatively lower population of Malaysia and the size of the country, comparing it with China is not entirely practical. Nevertheless, it helps to explain how they ended up differently within the regional production network. Malaysia started earlier than China and took the FDI-led model in the 1970s, and in the 1980s was ahead in terms of technology, with Penang clusters in the semiconductor and electrical industry and Japanese MNC production based in Malaysia. The growth of its E&E clusters slowed once other centres around the world also started to offer low labour costs to MNCs, as reflected in E&E industry's lower contribution to Malaysia's GDP from 2000 onwards. More importantly, much of Malaysia's E&E industry remains centred on foreign MNCs based in

Malaysia, which has a 'footloose'[63] problem, although the country is increasingly specialising in parts and components.

China only began to develop its E&E industry when it opened its doors to world trade in the 1980s. China has an import-substitution goal to reduce its dependence on foreign suppliers of E&E goods. It has imported semiconductor and television production lines in order to learn the production techniques and develop its own E&E industry. Simultaneously, China allows MNCs to invest in its E&E sector while promoting a transfer of technology from the MNCs to domestic enterprises. Chinese firms have strategically acquired semiconductor plants from foreign MNCs operating in China to obtain the technology. In some instances it has acquired foreign businesses outright, as in the Lenovo case, to accelerate entry into the international market for Chinese PCs.

Finally, China's electrical goods industry has developed white goods production, and Chinese companies such as CWG show that firms commonly start by manufacturing goods for MNCs (OEM strategy) before manufacturing their own brands. In short, China already has a stable of Chinese firms, which are international market players for finished goods such as computers, TV, and household electrical goods, but is playing catch-up in the semiconductor industry with major players from the US and Taiwan.

In spite of China being the world's biggest exporter of E&E products it is ambitiously building its own semiconductor industry, believing this to be a strategic industry for the future. Conversely, Malaysia is still reliant on FDI for its E&E industry, despite having had a head start in the E&E industry. It has tried and failed to indigenise the industry and build an international

[63] 'Footloose' refers to MNCs shifting location once the incentives run out at a location, shopping around for incentives in other regions or countries.

brand. While Malaysia is unable to break away from the FDI model of development, some private companies offer a potential starting point on which it can build. On the other hand, China has managed to indigenise household electrical goods and own international brands. While Malaysia’s role in the MNCs’ E&E value chain remains important, China is on a different trajectory towards its very own E&E industry.

5.0 Interactions between Malaysia and China in Electronic and Electrical Trade

In the Asian Drivers framework (see Chapter 2), China impacts on its neighbours through bilateral trade are regarded as the direct impact. The focus of Chapter 5 is on the interaction between Malaysia and China's bilateral trade.[64] This chapter discusses the bilateral trade patterns to identify the effect of China on Malaysia's E&E trade by examining their bilateral E&E trade structure disaggregated by sophistication and secondly, by type of goods, broadly reflecting complementary trade specialisation between the two countries.

Following Chapter 4, which discussed the evolution of Malaysia and China's E&E production network, this chapter examines China's impact on Malaysia's E&E industry. It begins with an overview of their total bilateral trade, based on a trade balance analysis for 1992-2013 and the major goods traded, with a discussion of the Malaysian export and import structure to and from China. Then the bilateral E&E trade structure and the E&E parts and components trade are disaggregated using the PRODY index as a measure of sophistication to evaluate signs of upgrading. Next, the chapter analyses E&E bilateral trade in terms of the balance of trade both at aggregate and disaggregated levels by type of goods, using the BEC classification to assess whether the structure of trade supports complementary specialisation. After that, I gauge the extent of penetration of China's imports into Malaysia, which are especially relevant for household electrical goods. The chapter also looks at the degree of integration between Malaysia's exports and China's imports before concluding that different segments of the E&E industry are affected

[64] Total bilateral trade here refers to total merchandise trade, including manufactured, mining and agricultural products, and excluding services.

differently in Malaysia's bilateral trade with China, although Malaysia benefits from specialising in exporting IC chips to China.

As background, China is currently Malaysia's number one trading partner by trade value. Table 5.1 below illustrates the rapid rise of the volume of China's trade with Malaysia in 1992, 2002 and 2013. [65] China has overtaken Malaysia's traditional trade partners such as Japan, USA, and Singapore to emerge as its top trading partner since 2009.

Table 5.1 China's position as Malaysia's Trading Partner – selected years

Trade Partner	1992 US$ bn	Trade Partner	2002 US$ bn	Trade Partner	2013 US$ bn
Japan	15.8	US	32.6	China	64.6
Singapore	15.7	Singapore	25.5	Singapore	57.3
US	13.9	Japan	24.6	Japan	43.2
Other Asia*	3.5	China	11.4	US	34.7
Germany	3.3	Other Asia*	7.9	Thailand	25.0
U. Kingdom	3.0	Hong Kong	7.7	Indonesia	19.4
Korea, Rep.	2.6	Korea, Rep.	7.3	Korea, Rep.	18.1
Thailand	2.5	Thailand	7.1	Other Asia*	16.7
Hong Kong	2.5	Germany	5.0	Australia	14.5
China	1.8	Indonesia	4.3	India	13.4
Other	15.9	Other	38.9	Other	128.0

Note: 'Other Asia' refers mainly to Taiwan.
Source: Based on UNComtrade data

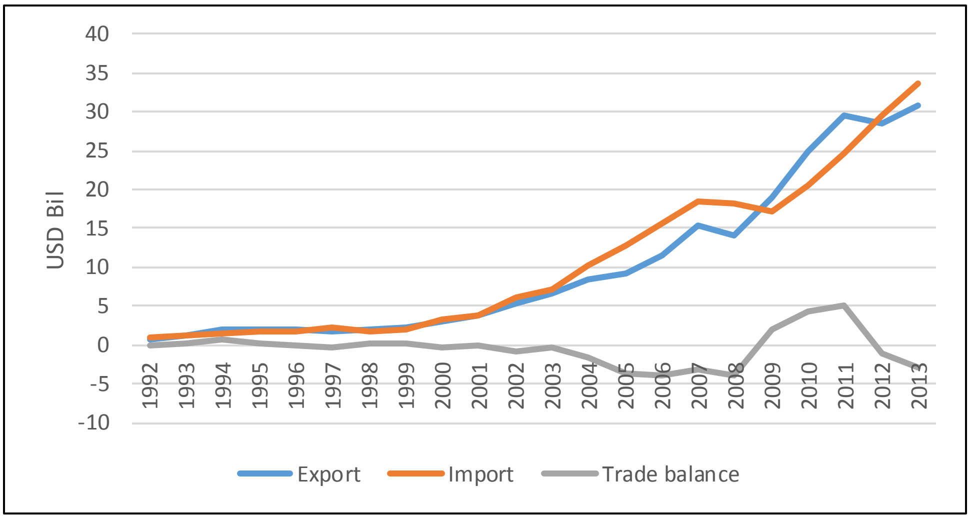
5.1 Bilateral Trade Between Malaysia and China at Total Merchandise Trade Level

Bilateral trade between Malaysia and China at the total merchandise trade level is discussed in this section to provide an overview. Bilateral trade between Malaysia and China grew rapidly from 1992-2013, as shown in Figure 5.1. In 1992-2013 Malaysia's exports to China grew by 19.2% p.a.,

[65] 'Trade' in this paragraph includes both exports and imports.

from US$0.8 billion in 1992 to US$30.8 billion in 2013, slightly faster than its imports from China, which increased at 18.4% p.a. from US$1.0 billion in 1992 to US$ 33.8 billion by 2013. By 2009 China had emerged as Malaysia's top trading partner. Overall, the increase in Malaysia's imports from China was followed with an increase in its exports into China, suggesting that China's bilateral trade with Malaysia generally avoided big trade imbalances.

Figure 5.1 Malaysia and China's Total Trade Balance (Malaysia as reporter country)



Source: UNComtrade

The trade balance between Malaysia and China from 1992-2013, shown in Figure 5.1 above, is evenly balanced from 1992-1999, with small deficits or surplus. However, from 2002, a year after China joined the WTO, Malaysia's trade deficit with China widened until 2008 before reverting to a surplus from 2009 -2011 and then falling back to a deficit again by 2012. Overall, Malaysia has experienced 13 years of trade deficit out of the 21 years. The size of the deficit never exceeded 18.0% of total bilateral trade or US$5 billion in any one year throughout the period 1992-2012, and in 16 of the 21 years it was less than 10% of total trade. Malaysia's trade surplus in the period starting from 2011 fell, due to commodity exports from

Malaysia to China decreasing both in price and quantity (MATRADE Malaysia, 2012).[66] Based on rising import and export volume coupled with the absence of a large trade deficit, Malaysia's experienced with China suggests that the overall trade relationship is mutually beneficial at the aggregate level.

Next, I tabulate the bilateral export and import structure by major HS chapters (at 2-digit level) to reveal major goods traded between Malaysia and China at product-level. There are 99 chapters of goods classified by HS Nomenclature at group level, but only top 10 products are listed.

Based on Table 5.2 below, Malaysia's exports to China confirm the centrality of E&E equipment (HS Chapter 85) as Malaysia's most important commodity over time. Malaysia's exports of *electrical, electronic equipment* (HS Chapter 85) to China are worth US$ 1.5 billion or 29.2% of total exports in 2002, rising to US$10.5 billion or 34.1% of total exports by 2013. As the E&E has the largest share to total exports, the E&E industry is the natural choice for my investigation of the effect of China's rise on Malaysia's manufacturing sector.

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[66] Based on China as reporter, the trade data shows export and imports to Malaysia also grew rapidly from 1992 to 2013, and this is consistent with Malaysia-sourced data. However, based on China as reporter, the trade balance between Malaysia and China has been quite even except in the period beginning from 2000, when bilateral trade begins to grow rapidly. China consistently has a trade deficit with Malaysia, which widens after 2009, but the trade deficit narrows again by 2012. Inconsistency in the trade figures between exports from Malaysia to China (Malaysia as reporter) compared with mirror imports data from Malaysia (China as reporter) is about US$30 billion. As the International Trade Centre ranks the reliability of Chinese trade data for HS Chapter 85 products, Machinery & Electronics as low (http://legacy.intracen.org/appli1/TradeCom/RS_TP_IC.aspx?IN=85&YR=2012&IL=85%20%20Electrical,%20electronic%20equipment accessed 6 May 2015), Malaysian data is used throughout this chapter.

Table 5.2 Malaysian Exports to China by Major Products (HS Chapter) (Malaysia as Reporter)

HS	Description	1992 US$ bn	HS	Description	2002 US$ bn	HS	Description	2013
44	Wood and articles of wood, charcoal	0.3	85	Electrical, electronic equipment	1.5	85	Electrical, electronic equipment	10.5
15	Animal, vegetable fats & oils, cleavage products	0.3	84	Nuclear reactors, boilers, machinery	0.9	15	Animal, vegetable fats & oils, cleavage products	3.3
27	Mineral fuels, oils, distillation products	0.1	15	Animal, vegetable fats & oils, cleavage	0.8	27	Mineral fuels, oils, distillation products	3.3
84	Nuclear reactors, boilers, machinery	0.03	27	Mineral fuels, oils, distillation products	0.6	84	Nuclear reactors, boilers, machinery	2.9
40	Rubber & articles	0.03	29	Organic chemicals	0.3	40	Rubber & articles	2.7
18	Cocoa & cocoa prep.	0.02	39	Plastics & articles	0.2	74	Copper & articles	2.0
85	Electrical, electronic equipment	0.01	44	Wood & articles of wood	0.2	29	Organic chemicals	1.4
55	Manmade staple fibres	0.01	40	Rubber & articles thereof	0.1	39	Plastics & articles thereof	1.1
29	Organic chemicals	0.01	72	Iron & steel	0.1	26	Ores, slag and ash	0.6
99	Commodity not specified	0.004	70	Glass & glassware	0.1	90	Optical, photo, technical, medical app	0.5
	Others	0.04		Others	0.5		Others	2.5
	Total	0.8		Total	5.3		Total	30.8

Note: HS = HS chapter

Source: Data from UNComtrade

Table 5.3 Malaysian Imports from China by Major Products (HS chapter) (Malaysia as Reporter)

HS	Description	1992 US$ bn	HS	Description	2002 US$ bn	HS	Description	2013 US$ bn
10	Cereals	0.2	85	Electrical, electronic equipment	2.0	85	Electrical, electronic equipment	12.2
12	Oil seed, oleagic fruits, grain, seed	0.1	84	Nuclear reactors, boilers, machinery	1.9	84	Nuclear reactors, boilers, machinery	6.6
84	Nuclear reactors, boilers, machinery	0.1	10	Cereals	0.3	72	Iron & steel	1.3
85	Electrical, electronic equipment	0.1	99	Commodities not specified	0.2	74	Copper & articles thereof	1.1
28	Inorganic chemicals, precious metal com.	0.04	27	Mineral fuels, oils, distillation products	0.1	90	Optical, photo, technical, med. app.	1.0
7	Edible vegetables & certain roots	0.04	39	Plastics and articles thereof	0.1	73	Articles of iron & steel	1.0
52	Cotton	0.04	90	Optical, photo, technical, medical ap.	0.1	39	Plastics & articles thereof	1.0
55	Manmade staple fibres	0.04	7	Edible vegetables & certain roots	0.1	76	Aluminium & articles thereof	0.7
72	Iron & steel	0.03	73	Articles of iron or steel	0.1	27	Mineral fuels, oils, distillation	0.7
26	Ores, slag and ash	0.03	28	Inorganic chemicals, precious metal com.	0.1	87	Vehicles other than railway, tramway	0.7
	Others	0.4		Others	1.3		Others	7.6
	Total	1.0		Total	6.1		Total	33.8

Note: HS = HS Chapter

Source: Data from UNComtrade

Based on

Table 5.3 above, which compares 1992, 2002 and 2013, the structure of Malaysia's imports from China shows signs of upgrading. The top item imported from China to Malaysia has shifted from cereals in 1992 to E&E products. Furthermore, Malaysian imports of primary products imported from China in 1992 ranging from *Cereals* to *Ores, Slag and Ash* have not been in the top 10 items imported from China since 2002. On the other hand, Malaysia's top exports items to China shifted from exporting mainly *Wood and articles of wood, charcoal* in 1992 to E&E products in 2013.

Contrasting both the export (Table 5.2) and the import structure (

Table 5.3), China shows signs of upgrading its export structure to Malaysia, while Malaysia's exports to China remains centred on E&E over time. This is based on a comparison of the second top exported and imported items in 2013: Malaysia's imports include more machinery (HS Chapter 84) from China both in 2002 and 2013. In contrast, Malaysia increasingly exports *Animal, vegetable fats & oils, cleavage products* (HS Chapter 15), which replaces machinery (HS Chapter 84) in the no. 2 spot in 2013. The slip in the ranks of Malaysian machinery (HS Chapter 84) exports to China is a concern, although this does not deny the benefits from increasingly Malaysian specialisation in E&E exports.

Malaysia's increased exports to China in *Animal, vegetable fats & oils* and *Mineral fuels, oils, distillation products* (the third most valuable export chapter) in 2013 in Table 5.2 above brings us back to the concern of the rising primarisation. This resonates with Ianchovichina et al.'s (2010) prediction that Malaysia will benefit from rising primary commodity prices but suffer in the manufacturing sector as China rise and competes for trade. Scholars such as Jenkins and De Freitas Barbosa (2012) have raised similar concerns about the primarisation of the economy, especially in

Latin America. However, Thoburn (2011) notes that Malaysia had largely escaped the primarisation effect by developing its manufacture exports.

To conclude this section, China's effect on Malaysia in their total bilateral trade is generally positive. At the total trade level, China's trade with Malaysia is largely beneficial, with a rising volume of trade between the two. There are no huge trade imbalances such as that experienced between the US and China. In addition, rising share of E&E trade against total trade between Malaysia and China is a preliminary indication of complementary trade within the regional production network. However, given the Malaysian concern about the primarisation of Malaysia's economy this research examines E&E manufacture exports in the next section.

5.2 Malaysia and China's E&E trade

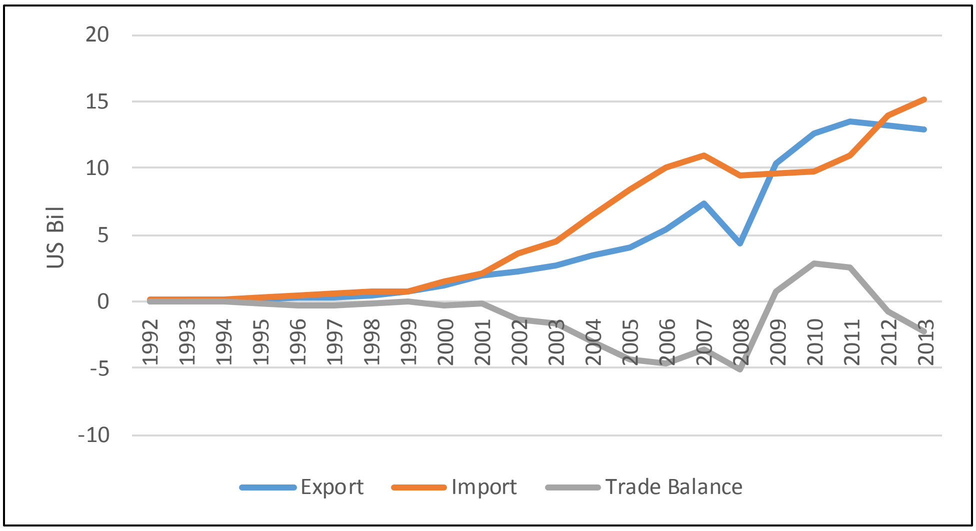
I focus on the bilateral E&E trade between Malaysia and China in this section. Specifically, the E&E sector consists of 338 product lines based on HS codes at 6-digit level, covering both electronics, such as the semiconductors industry, and the electrical sector, which consists of household electrical goods. A full list of E&E goods is provided in Appendix 3.1.

The objective of this section is to understand the structure of the E&E trade between Malaysia and China. The trade structure is disaggregated by measure of sophistication to better understand the goods traded both at total E&E level (338 products) and at the E&E parts and components level (81 products of the 338 products). Towards the end of the section the trade balance is disaggregated by BEC classification to reveal Malaysia's areas of specialisation. I conclude the section by discussing how far

Malaysia and China's bilateral E&E trade structures support the complementary view of the regional production network.

At the aggregate level, Malaysia's exports and imports from China in their E&E bilateral trade increases over the years from 1992-2013, especially after 2000 (see Figure 5.2 below). E&E exports from Malaysia to China grow on average by 33.0% per annum from US$0.03 billion in 1992 to US$12.9 billion by 2013. As a share of total Malaysian exports to China, E&E rose from 4.2% in 1992 to 41.9% in 2013, while Malaysia's E&E imports from China rise from US$0.07 billion in 1992 to US$15.14 billion by 2013, with an annual growth rate of 29.2%. The share of total E&E imports from China to Malaysia is only 7.2% in 1992, rising to 45.1% by 2013. The high proportion of Malaysia's E&E exports and imports in its total trade with China confirms E&E as its most important manufacturing sector.

Figure 5.2 E&E Trade Balance (Malaysia as Reporter)



Note: Exports from China to Malaysia are include 327 products, while imports from China to Malaysia include 338 products: Malaysia does not export 11 of the 338 products to China.

Source: UNComtrade

When the E&E bilateral trade is analysed, the trade balance is found to be in favour of China because Malaysia records a deficit for most of the years except for 1999, 2009, 2010, and 2011, as shown in Figure 5.2 above. The trade deficit also noticeably widens year after year from the year China joins the WTO in 2001 until 2008.

Next, the bilateral trade in E&E is analysed at product level in Table 5.4 and

Table 5.5 below, which tabulate the top ten products by value in the HS Code. The tables reveal that parts and components for the computer industry have been actively traded both ways from 2002 onwards. This is consistent with the earlier findings of scholars such as Cui and Syed (2007) that China is not merely a centre for the assembly trade but is also capable of producing and exporting parts and components, in this case to Malaysia. For example, Malaysia exported *Monolithic integrated circuits, except digital,* under semiconductor industry to the value of US$ 8.1 billion (see Table 5.4), and while it imports *Parts and accessories of data processing equipment* to the value of US$4.1 billion in 2013 (see

Table 5.5). *Data processing equipment* primarily includes the computer industry, and these parts and components are more sophisticated *than Filament lamps, except ultraviolet or infra-red* and *Colour cathode-ray television picture tubes, monitors,* formerly the top imports from China in 1992 and in 2002 respectively. respectively. While the tabulation of top imported items from China in

Table 5.5 cannot immediately conclude that China has upgraded its export structure, China has stepped up its export of parts and components to Malaysia; contrary to expectations, it is at the receiving end of parts and components and assembles them into final products under a regional production framework (Athukorala and Kophaiboon, 2014).

Table 5.4 Malaysia's Major E&E Exports to China, Malaysia as Reporter

HS code	Description	1992 US$ bn
841510	Air conditioners window/wall types, self-contained	0.014
852990	Parts for radio/tv transmit/receive equipment, nes	0.004
852520	Transmit-receive apparatus for radio, TV, etc.	0.002
900691	Parts and accessories for photographic cameras	0.001

847330	Parts and accessories of data processing equipment ne	0.001
852810	Colour television receivers/monitors/projectors	0.001
853710	Electrical control and distribution boards, < 1kV	0.001
852790	Radio reception apparatus nes	0.001
847199	Automatic data processing machines and units, nes	0.001
854449	Electric conductors, nes < 80 volts, no connectors	0.001
	Others	0.006
	Total	0.032
HS code	Description	2002 US$ bn
847330	Parts and accessories of data processing equipment nes	0.6
854211	Monolithic integrated circuits, digital	0.6
854290	Parts of electronic integrated circuits etc.	0.2
853400	Electronic printed circuits	0.2
854219	Monolithic integrated circuits, except digital	0.1
847199	Automatic data processing machines and units, nes	0.1
852990	Parts for radio/tv transmit/receive equipment, nes	0.1
854011	Colour cathode-ray television picture tubes, monitors	0.1
852520	Transmit-receive apparatus for radio, TV, etc.	0.0
851782	Telegraphic apparatus, nes	0.0
	Others	0.3
	Total	2.3
HS code	Description	2013 US$ bn
854219	Monolithic integrated circuits, except digital	8.1
847193	Computer data storage units	1.5
847330	Parts and accessories of data processing equipment nes	0.4
854290	Parts of electronic integrated circuits etc.	0.4
847199	Automatic data processing machines and units, nes	0.3
853400	Electronic printed circuits	0.3
854140	Photosensitive/photovoltaic/LED semiconductor dev.	0.3
850780	Electric accumulators, nes	0.1
854129	Transistors, except photosensitive, > 1 watt	0.1
851790	Parts of line telephone/telegraph equipment, nes	0.1
	Others	1.3
	Total	12.9

Source: UNComtrade

Table 5.5 Major E&E Product Imports from China, Malaysia as Reporter

HS code	Description	1992 US bn
853929	Filament lamps, except ultraviolet or infra-red, nes	0.011
850110	Electric motors of an output < 37.5 watts	0.007
854020	Television camera tubes and other photo-cathode tube	0.003
852711	Radio receivers, portable, with sound reproduce/ recording	0.003
851610	Electric instant, storage and immersion water heaters	0.002
850161	AC generators, of an output < 75 kVA	0.002
850431	Transformers electric, power capacity < 1 KVA, nes	0.002
853225	Electric capacitors, fixed, paper/plastic dielectric	0.002
854011	Colour cathode-ray television picture tubes, monitors	0.002
854449	Electric conductors, nes < 80 volts, no connectors	0.002
	Others	0.036
	Total	0.07
HS code	Description	2002 US bn
854011	Colour cathode-ray television picture tubes, monitors	1.1
852990	Parts for radio/tv transmit/receive equipment, nes	0.3
850423	Liquid dielectric transformers > 10,000 KVA	0.2
850110	Electric motors of an output < 37.5 watts	0.2
854460	Electric conductors, for over 1,000 volts, nes	0.2
852731	Radio-telephony receiver, with sound reproduce/ recording	0.1
850140	AC motors, single-phase, nes	0.1
852711	Radio receivers, portable, with sound reproduce/ recording	0.1
847330	Parts and accessories of data processing equipment nes	0.1
853340	Variable resistors, rheostats and potentiometers, nes	0.1
	Others	1.1
	Total	3.6
HS code	Description	2013 US bn
847330	Parts and accessories of data processing equipment nes	4.1
852731	Radio-telephony receiver, with sound reproduce/ recording	1.0
854460	Electric conductors, for over 1,000 volts, nes	1.0
854011	Colour cathode-ray television picture tubes, monitors	1.0
850110	Electric motors of an output < 37.5 watts	1.0
851829	Loudspeakers, nes	0.7
854219	Monolithic integrated circuits, except digital	0.7
850140	AC motors, single-phase, nes	0.6
850434	Transformers electric, power capacity > 500 KVA, nes	0.4
853661	Electrical lamp-holders, for < 1,000 volts	0.3
	Others	4.6
	Total	15.1

Source: UNComtrade

5.2.1 E&E Trade by Disaggregated by Sophistication

As E&E is actively traded both ways between Malaysia and China, the next question is whether they export different E&E products to each other, distinguished by level of sophistication using the PRODY index, which is used to divide the 338 products in E&E into 4 quartiles. Products listed in Quartile 1 are the most sophisticated, while products listed under Quartile 4 are the least sophisticated. Based on Hausmann et al. (2007), the PRODY index is a 'weighted average of the per capita GDPs of exporting countries' earned from a specific product. Detail formula of the PRODY index is available in Chapter 3.

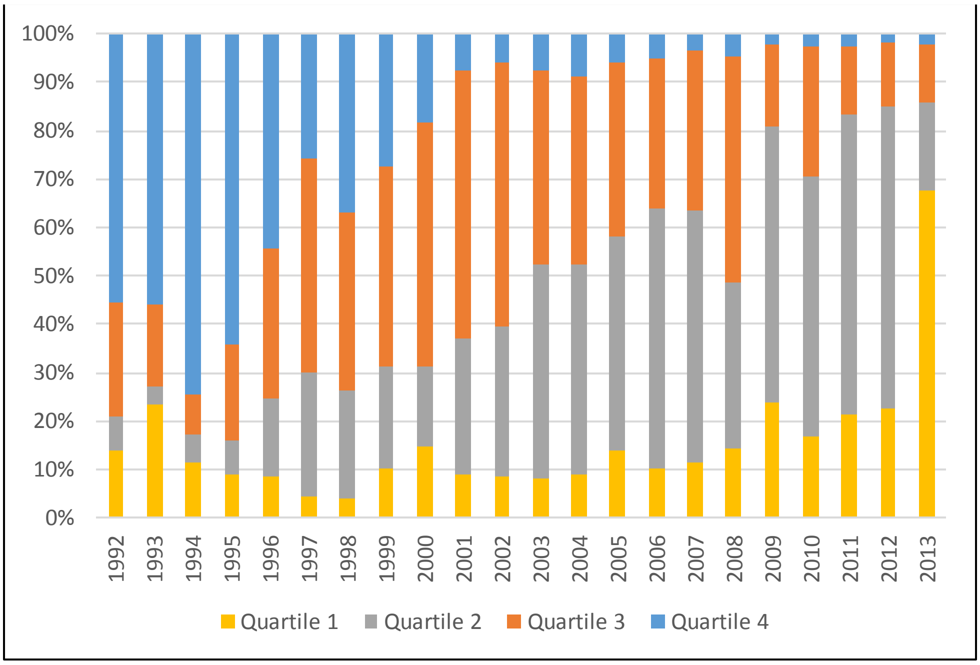
Based on Figure 5.3 and Figure 5.4, the share of the most sophisticated (represented by Quartile 1) and the least sophisticated goods (Quartile 4) in the E&E trade between Malaysia and China is disaggregated. The disaggregation divides the bilateral trade structure over time based on sophistication. The revealed structure of E&E trade disaggregated by sophistication will show whether Malaysia is feeding China with more sophisticated parts and components in the regional production framework.

The main finding reveals that Malaysia has gradually exported more sophisticated goods such as ICs to China, especially in 2008-2013, while receiving less sophisticated goods, e.g. portable audio products such as MP3 players, as imports. Cascading the analysis to the level of trade in E&E parts and components, the picture is consistent with overall E&E trade, with Malaysia exporting more sophisticated parts and components while importing less sophisticated parts and components.

Malaysia exports more sophisticated E&E products to China over time based on the rising proportion of more sophisticated E&E exports to total exports. Figure 5.3 shows that Malaysia is exporting more E&E items from

Quartiles 1 and 2 over time, while the contribution of Quartiles 3 and 4 to total E&E exports drops. For example, the share of E&E products under Quartile 4 fell from above 50.0% of total E&E exports in 1992 to less than 10.0% in 2002. In 2013, Quartile 4's contribution to E&E exports is less than 3.0%. Conversely, the share of products in Quartiles 1 and 2 rose from 20.9% in 1992 to 85.7% of total E&E exports in 2013.[67]

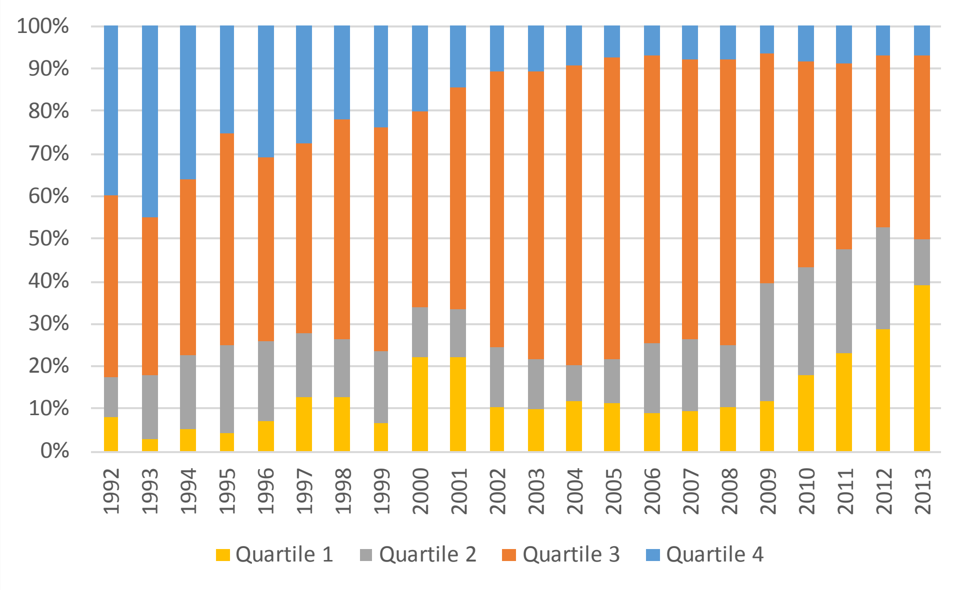
Figure 5.3 Malaysia's E&E Export to China Disaggregated by Level of Sophistication



Source: Based on UNComtrade data

[67] The export data is mostly discussed as a combination of Quartile 1 and Quartile 2 because HS 854211 is in PRODY Quartile 2 and HS 854219 is in Quartile 1. The data are becoming distorted for 2013 as the value of export HS 854211 for trade suddenly falls from US$5.5 billion down to US$0.007 billion, but the value of product code 854219 jumped from US$ 2.3 billion to US$8.1 billion from 2012 to 2013. This distortionary effect can be seen in Quartile 1's sudden rapid climb from 2012 in Figure 7. The data are likely to be affected by the reclassification rather than actual product movement. This is evident when we add HS 854211 and HS 854219 together for which the value of trade in 2012 is US$7.7 billion and in 2013 is US$ 8.1 billion.

Figure 5.4 Malaysia's E&E Import from China Disaggregated by Level of Sophistication



Source: Based on UNComtrade data

The structure of Malaysia's imports from China also shows signs of product upgrading in its E&E sector, albeit at a slower pace than Malaysia's export upgrading. Based on Figure 5.4 above, the share of Quartile 1 and 2 imports from China is growing over the years with 17.5% of Malaysia's imports of E&E from China in 1992 from goods in Quartiles 1 and 2, rising to 29.6% by 2013. However, the combined share from Quartiles 3 and 4 remains equal at above 50.0% of total imports of E&E products throughout 1992-2013, except in 2012, at 47.2%. This shows that Malaysia is receiving less sophisticated E&E imports from China than its E&E exports to China.

To illustrate the pace of export upgrading by Malaysia more clearly, Table 5.6 divides the average share of exports and imports from China in 1992-2013 into four sub-periods: 1992-1996, 1997-2001, 2002-2007 and 2008-2013. Two thousand and one was a significant year, as China joined the WTO, signalling its entry into international trade in a huge way. The average share of Quartile 2 jumps from 22.9% in 1997-2001 to 44.6% of total E&E exports in 2002-2007, and Quartile 4's average share correspondingly drops from 23.2% to 6.1% of total E&E exports. Moreover, the share of the combined average of Quartiles 1 and 2 in total E&E exports rises rapidly from 54.9% in 2002-2007 to 75.7% in 2008-2013. Correspondingly, the average combined share of Quartiles 3 and 4 falls from 45.1% in 2002-2007 to 24.3% in 2008-2013. Malaysia's E&E export structure displays signs of upgrading to greater sophistication over time during 1992-2013, with the immediate period of China's entry into the WTO (2002-2007) increasing the proportion of more sophisticated export goods at the expense of less sophisticated E&E exports. This points to Malaysia's adjustment to international trade as China entered the WTO by upgrading its exports.

Table 5.6 Average Share of Malaysia's Export and Import of E&E to/from China by PRODY Quartile

Export	**Average share of E&E exports**				
Quartile	1992-2013	1992-1996	1997-2001	2002-2007	2008-2013
Quartile 1	15.3%	13.4%	8.5%	10.3%	27.7%
Quartile 2	32.2%	7.8%	22.9%	44.6%	48.0%
Quartile 3	31.4%	19.9%	45.5%	39.0%	21.6%
Quartile 4	21.1%	59.0%	23.2%	6.1%	2.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Import	**Average share of E&E imports**				
Quartile	1992-2013	1992-1996	1997-2001	2002-2007	2008-2013
Quartile 1	13.5%	5.5%	15.3%	10.3%	21.9%
Quartile 2	16.2%	16.3%	13.7%	13.0%	21.2%
Quartile 3	53.0%	42.9%	49.5%	68.0%	49.5%
Quartile 4	17.3%	35.3%	21.5%	8.7%	7.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Based on UNComtrade

In the imports segment of Table 5.6 above, although Malaysia's E&E imports from China increasingly come from Quartiles 1 and 2, the majority are still products of lower sophistication from Quartiles 3 and 4. This is not much different from the conclusion that can be drawn from the contribution averages for the entire 1992-2013 period with the average share of imports disaggregated by sophistication and divided into four sub-periods, except for 2008-2013, following the global financial crisis, when China stepped up its more sophisticated E&E exports to Malaysia. The average share of Quartile 1 jumps from 10.3% in 2002-2007 to 21.9% of total E&E imports in 2008-2013 and likewise for Quartile 2, which jumps from 13.0% in 2002-2007 to 21.2% in 2008-2013. Overall, Malaysia receives less sophisticated E&E product imports from China but the increased sophistication of its imports since 2008 should concern Malaysia, especially regarding Chinese exports of E&E parts and components, Malaysia's area of specialisation. This is discussed next.

The analysis of Malaysia's E&E exports and imports from China disaggregated by sophistication is repeated for parts and components. Parts and components here are the HS codes concorded to the BEC Classification Code Chapter 42 *Parts and Accessories*. The results mirror the findings for total E&E: Malaysia is sending out more sophisticated exports while receiving less sophisticated E&E imports from China. A point to note in Table 5.7 below, is that Malaysia's exports of parts and components to China as a share of total E&E exports is more important than its imports from China.[68] Average export value is US$3.4 billion from 1992-2013, or 67.2% of total E&E exports, while average imports from 1992-2013 is

[68] As the years progress from 1992-2013, capital goods as a share of Malaysia's total E&E exports to China decline while the share of parts and accessories increases. For Malaysia, capital goods retain a sizeable share of 24.7-37.2% of total E&E imports from China in 1992-2013.

US$3.3 billion, or 57.8% of total E&E imports. Table 5.7 presents the details.

Table 5.7 Average Share of Contribution of Malaysia's Export and Imports of Parts and Components to/from China by PRODY Quartile (Sophistication)

Exports	**Average Share of Parts & Components of E&E**				
Quartile	1992-2013	1992-1996	1997-2001	2002-2007	2008-2013
Quartile 1	16.5%	16.7%	3.8%	9.9%	33.5%
Quartile 2	29.2%	10.9%	19.9%	44.0%	37.4%
Quartile 3	39.4%	41.3%	50.0%	41.5%	26.9%
Quartile 4	14.9%	31.0%	26.3%	4.7%	2.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Imports	**Average Share of Parts & Components of E&E**				
Quartile	1992-2013	1992-1996	1997-2001	2002-2007	2008-2013
Quartile 1	10.8%	6.1%	6.8%	8.6%	20.2%
Quartile 2	13.2%	12.9%	11.2%	8.0%	20.2%
Quartile 3	59.3%	38.3%	61.2%	78.1%	56.6%
Quartile 4	16.7%	42.8%	20.8%	5.3%	3.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Based on UNComtrade

Based on Table 5.7 above, imports from China grow in sophistication significantly during 2008-2013 compared to other earlier sub-periods. Quartiles 1 and 2 accelerate their contribution in 2008-2013, with their collective average share more than doubling from 16.6% of total parts and components exported in 2002-2007 to 40.4% of total parts and component exports in 2008-2013. The growing sophistication of China's parts and components imports into Malaysia is mostly driven by rising semiconductor imports.

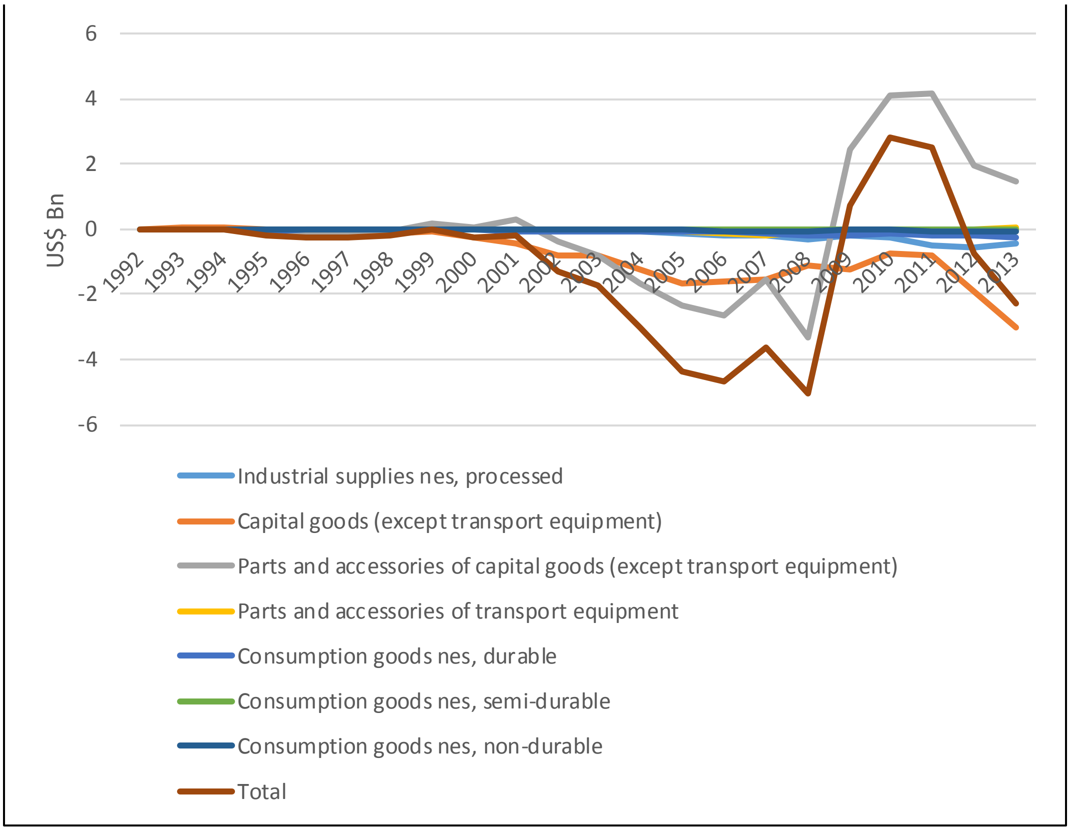
Stepping back from the trade balance frame of analysis, the increase in China's parts and components exports to Malaysia cannot be interpreted as completely negative. As Malaysia's strength is semiconductor testing and assembly, the increase in imports (in particular of fabricated wafers) feeds into Malaysia's exports of semiconductors as long as the trade balance remains positive. The balance of the bilateral trade in semiconductors between Malaysia and China is positive for all years except 2008, which has a small deficit of US$0.18 billion. Details of the trade balance for semiconductors are provided in Appendix 5.1.

In conclusion, based on analysis of the sophistication of Malaysia and China's bilateral E&E trade Malaysia exports more sophisticated goods to China while receiving less sophisticated goods as imports. This pattern is consistent in the E&E parts and components trade as well. However, Malaysia should note that post-2008 China steps up its export sophistication, mainly due to the increase in its exports of semiconductors to Malaysia.

5.2.2 Balance of E&E Trade Analysed by Broad Economic Category (BEC)

This section considers the bilateral E&E trade balance disaggregated by BEC classification. The objective here is to disaggregate the export and import structure by type of goods to see if E&E trade is broadly consistent with the regional production network's complementary trade, which states Malaysia specialises in exporting parts and components and importing final goods from China. The main finding here is that Malaysia's E&E exports are in a trade deficit except in 1999 and 2009-2011, as shown in Figure 5.5. Malaysia has a reversal of trends from deficit back into surplus from 2009 to 2011 aided by the *Parts and Accessories (except transport equipment)* category in its bilateral E&E trade with China, although the surplus is not sustainable beyond 2012. Malaysia also loses its competitiveness in the *Consumption Goods* category, which covers most household electrical items. Although this may be due to regional production arrangements, with Malaysia receiving finished goods in exchange for its parts and components, Malaysia's overall E&E deficit (except for 1999 and 2009-2011) means its export of parts and components cannot offset the total bilateral E&E trade deficit. Details of the export and import structure by type of goods are available in Appendix 5.2.

Figure 5.5 E&E Balance of Trade Disaggregated by BEC classification



Source: UNComtrade

The bilateral trade balance analysis based on the type of goods extends from the regional E&E industry picture where China's neighbours such as Malaysia generally feed parts and components into China's final assembly arrangement. While Athukorala (2009) finds that the trade of parts and components for machinery in general fits China, as a centre for the final assembly of finished goods while importing parts and components from predominantly East Asian countries including Malaysia, the E&E trade balance data dissected here by BEC classification extends our understanding. Malaysia imports more E&E products from China than it exports to China for most of the years. Apart from 1999-2001 and 2009-2013, Malaysia is not a net exporter of E&E *Parts and Accessories (except transport equipment)* under BEC Code 42 to China.

Based on further disaggregation of *Parts and Accessories (except transport equipment)* at product level (see Figure 5.6), Malaysia is a net importer of parts and components (excluding *Monolithic Digital Integrated Circuits*-HS 8542 products), especially after China joined the WTO in 2001. A sharp reversal from trade deficit to trade surplus in 2009 in *Parts and Accessories (except transport equipment)* was aided by the surge in export demand for *Monolithic Digital Integrated Circuits* (HS 854211 and HS 854219). This trade surplus continues to rise in 2010, driven by sharp increase in exports of *Parts and accessories of the machines of heading No. 84.71* (HS 847330) – which are basically computer parts – and *Photosensitive/photovoltaic/ LED semiconductor devices* (HS 854140) in 2010.[69] However, the surge is not sustainable, and *Parts and accessories of the machines of heading No. 84.71* (HS 847330) revert to a trade deficit by 2011, while the *Photosensitive/photovoltaic/LED semiconductor devices* (HS854140) trade surplus narrows significantly. Malaysia consistently experiences a trade deficit in *Parts for radio/tv transmit/receive equipment, nes* (HS 852990) throughout 1992-2013, which notably increases after 2001, and the *Electronic printed circuits* (HS 853400) deficit also increases from 2003 onwards.[70]

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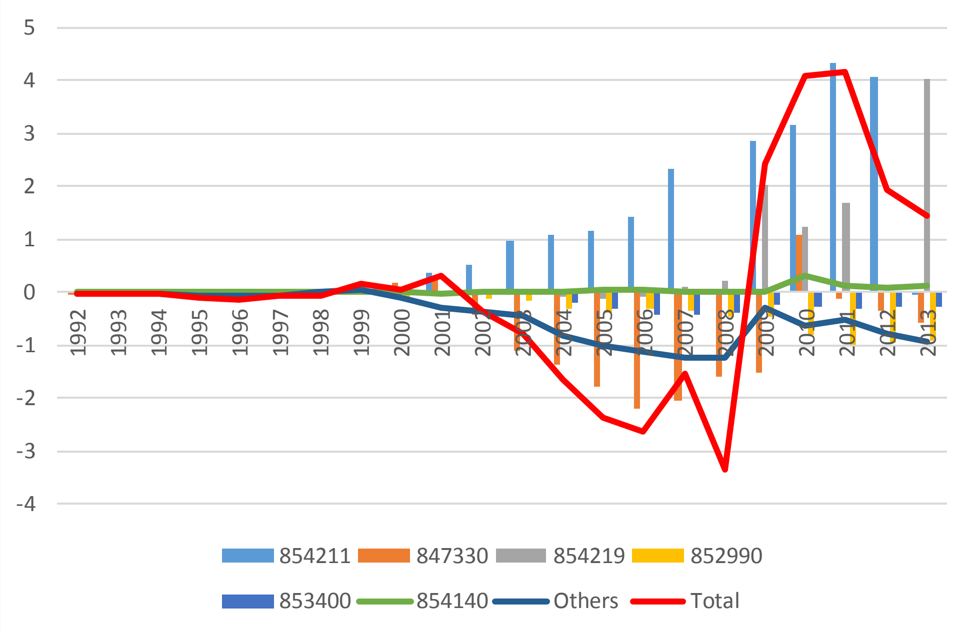
[69] Parts for automatic data processing machines; for example network cards or display cards for computer assembly.
[70] Chapter 8's section on firms' entry into and exit from in Penang partially explains why HS 853400 deficit is widening.

Figure 5.6 Balance of Trade in Parts and Components BEC42 for Selected Products



Note: total in the figure 14 above refers to sum of HS codes listed in concordance with BEC 42. For details, refer to Appendix 5.2 and Appendix 5.4.

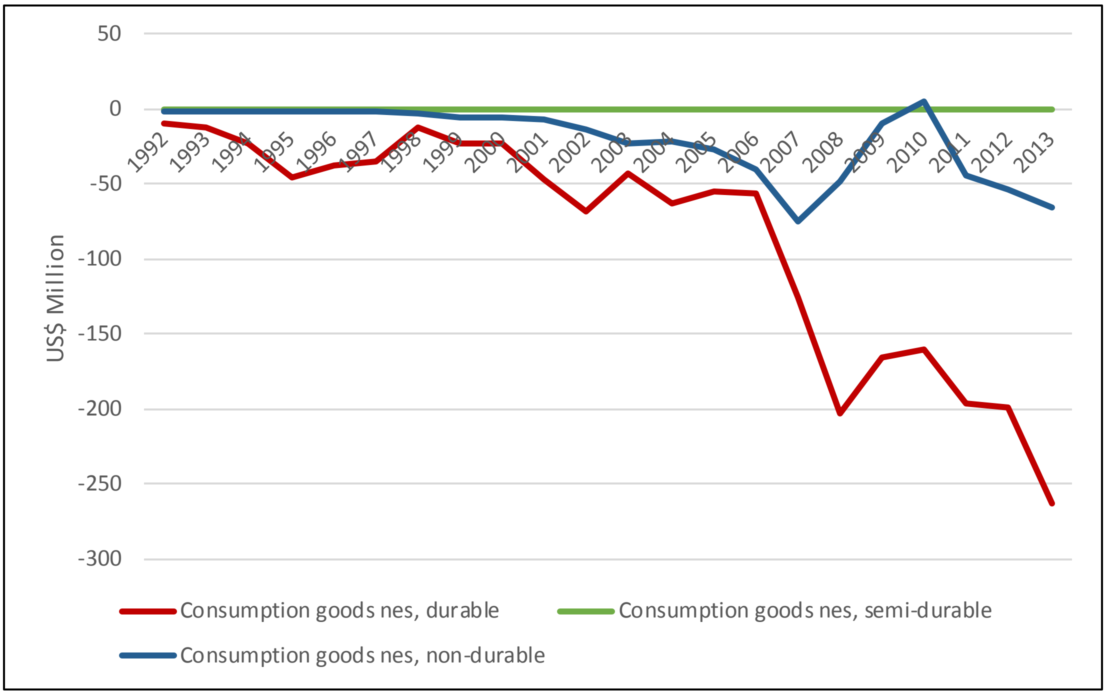
Source: UNComtrade

However, counter-intuitively, *photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels, light emitting diodes* (HS 854140) is in trade surplus despite it being well known that China is a global player in the solar industry. However, the size of the surplus is insignificant at less than US$300 million at its peak in 2010. The data at 6-digit level, however, includes both LED devices and solar photovoltaic modules and it is therefore hard to conclude that either one of the products could be in surplus. This is interesting, given that Malaysia also hosts many North American and Japanese solar photovoltaic manufacturers. At the combined level of solar photovoltaic modules and LED products, Malaysia exports more to China than it receives from it as imports.

In short, Malaysia continues to experience a trade surplus with China in E&E parts and components, mainly due to its ICs exports ((HS 854211 and HS 854219) and the insignificant surplus in photovoltaic/LED products. The rest of the parts and components industry is in favour of China. This part and components segment excluding ICs is inconsistent with previous writers' generalisation, such as that of Athukorala (2009), of the machinery sector as part of global production sharing arrangements. Instead, the part and components analysis at bilateral trade level lends credence to Lall and Albaladejo (2004) argument that middle-technology Malaysian exports are under threat. However, it is premature to conclude this before the results of the analysis of the share of imports at destination markets are considered in Chapter 6.

When the *Consumption Goods* category is further disaggregated into sub-categories, as shown in Figure 5.7 below, the trade balance is in favour of China. The Durable Goods sub-category of Consumption Goods, which contains mostly household electrical goods, faces a widening deficit with China since 1992, and this widened significantly once China joined the WTO in 2001. In 1992 the deficit in durables goods is US$1.9 million, rising to US$68.8 million in 2002, and by 2013 it reaches US$263.2 million. These finished products are the direct opposite of *Monolithic Digital Circuits*, which has fared positively as a result of China's rise in the region.

Figure 5.7 E&E Balance of Trade in Consumption Goods by BEC classification



Source: UNComtrade

While Malaysia and China both benefit from the rising volume of E&E trade over time, Malaysia experiences a trade deficit in most years. This deficit notably widens after China's entry into the WTO in 2001 until 2008, before swinging back into a Malaysian trade surplus in 2009-2011, aided by the rise in demand for ICs. Malaysia's E&E trade balance for had slipped back into a deficit by 2012 with E&E parts and components unable to offset imports of E&E goods in other categories. Details of the trade balance are available in Appendix 5.5.

While the regional production network literature, infers that China's neighbour such as Malaysia feeds parts and components into China for the assembly of final goods is broadly reflective of the complementary E&E trade, the analysis above finds that China has also stepped up its exports of parts and components to Malaysia, especially since 2008. However, Malaysia exports more sophisticated E&E (in total and as parts and components) while receiving less sophisticated imports from China.

A final note: although Malaysia's bilateral E&E trade with China is mostly in deficit (except in 1999 and 2009-2011), while it imports more from China, it processes these parts and components and ships them it to third destinations as discussed in Section 6.5 under Chapter 6 that refers to Malaysia's response in the colour television market. The import penetration of Chinese goods into Malaysia's E&E sector in the next section further examines the effect on Malaysian E&E players in the household electrical sector.

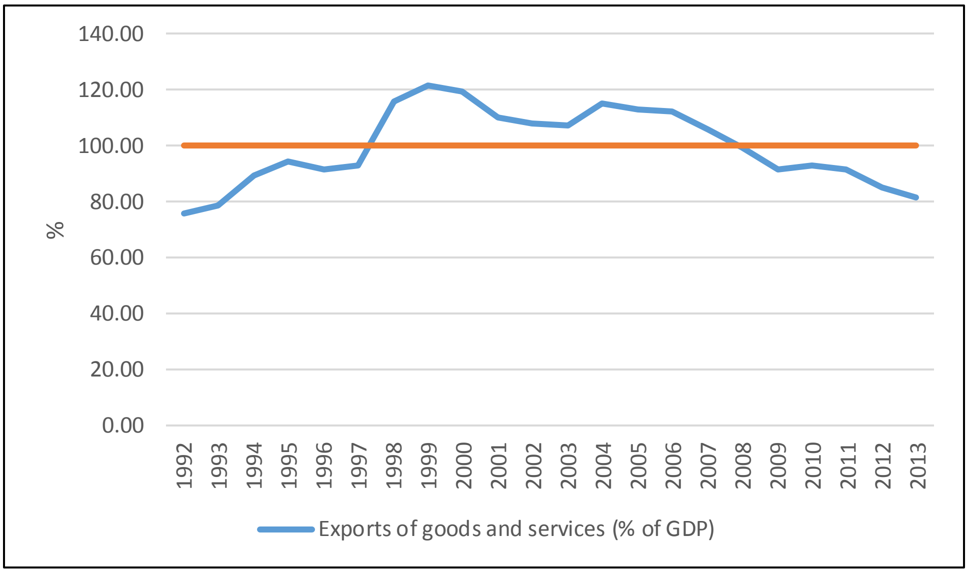
5.3 Import Penetration of Chinese Imports into Malaysia's E&E sector

The balance of trade analysis disaggregated by BEC classification finds that different types of E&E products fare differently in the trade balance between Malaysia and China. The objective here is to gauge the proportion of Chinese imports in Malaysia's apparent consumption of E&E products. The OECD (2010) says that embedded in this rate of import penetration is comparison of the competitiveness of imported goods with that of local firms endeavouring to keep their market share. A higher percentage of import penetration from China means that increased competitiveness of Chinese exports in Malaysia's domestic market, while a lower import penetration rate in Malaysia over time means that Chinese exports in Malaysia are losing their competitiveness.

Import penetration of China is measured as a percentage of total apparent consumption of products aggregated in a sub-industry within the E&E sector. Apparent consumption is defined as production plus imports minus exports. The detailed formula for apparent consumption and import penetration is given in Section 3.1.2 under Chapter 3.

While some percentages in the results (Table 5.8 and Table 5.9) are high, this is expected in a small open economy such as Malaysia (OECD, 2010). The openness is reflected in Malaysia’s export/GDP ratio, which exceeds 100% in some years, as shown in Figure 5.8 below. This apparently impossible percentage – with the country appearing to export more than it produces in aggregate - reflects the substantial import content of Malaysian exports, since exports are measured gross while GDP is a value-added concept.

Figure 5.8 Malaysia Exports/GDP Ratio



Source: Data from World Bank World Development Indicators

This exercise gauges China’s impact on different sub-industries within the E&E sector based on whether the trend of Chinese import penetration is increasing or decreasing, by type of product over time. The import penetration results are more useful for gauging China’s impact on the household electrical sector than on semiconductors, because semiconductors may cross the border several times before becoming finished goods. Monolithic Integrated Circuits can cross the border in wafer form for further processing to be re-exported once they are packaged into a complete IC. In contrast, final goods such as household electrical goods usually cross the border from China into Malaysia for consumption.

I used two concordance table for the data on apparent consumption and share of Chinese imports in Malaysia's E&E. The first concordance table from HS1998/92 to HS 2002, to convert trade codes denominated in HS2002 back into HS1998/92 codes. Next, E&E codes based on HS1998/92 codes were matched to their 5-digit Malaysia Standard Industrial Classification 2000 (MSIC) codes using the second concordance table from HS1998/92 to International Standard for Industrial Classification Rev. 3 (ISIC Rev.3).[71] I also used the ISIC Rev. 3 codes as a 'cross-walk' between HS and MSIC codes, because MISC codes are based on ISIC Rev. 3 codes.[72] The use of the MSIC 2000 codes limits the data period to 2002 onwards, as the closest revision of HS nomenclature to the year 2000 is the HS2002. In some product codes, judgement had to be exercised because the ISIC Rev.3 codes only have up to 4 digits, while the MSIC codes can sub-divide into 5 digits, but this is not a major issue as most 5-digit MSIC codes are obtained by adding a zero on the end of the 4 digit ISIC codes. All concordance tables were obtained from the World Bank WITS website.[73] The results for apparent consumption are shown in Table 5.8 and the percentages of China's import penetration of the E&E sector is presented in Table 5.9.

There are limitations to this exercise. Firstly, crossing from production data to trade data is not a straightforward exercise. The main issue is that Malaysia's Standard Industrial Classification (MSIC) codes are a coding of

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[71] Five codes out of the 338 are not available when converting them from HS 1998/92 to HS 2002. As a result these codes had to be dropped. HS 846929, 850620, 850890, 851781, and 900721 are however not significant items in the E&E sector, and have generally been discontinued due to changes in the industry.

[72] The term 'cross-walk' is used by Muendler and this refers to process of matching the trade codes with the production codes (Muendler, 2009).

[73] Source of concordance tables: http://wits.worldbank.org/product_concordance.html

industrial activity in production, while exports and imports are based on HS codes, which are a coding of goods. Therefore some of the MSIC codes used to produce Malaysia's Monthly Manufacturing Survey contain both electronic and non-electronic items. The apparent consumption results tabled in this section, however, do not include non-electronic items in the trade variables, allowing the conclusion to be based precisely on the E&E sector.

Secondly, while the data on imports includes re-imports, the data from the UNComtrade database on Malaysian exports does not exclude re-exports. This means that the exports are most probably overstated, and as a result apparent consumption is understated. Consequently, this can overstate China's import penetration due to the lower denominator in each industry's MSIC codes. Some cells in Table 5.8 and Table 5.9 are shaded grey; these observations have been dropped because apparent consumption goes into the negative due to underestimation of apparent consumption. A special note on the results for *Automatic Data Processing-Computers* (MSIC 30002), which show negatives for three years due to confidentiality of information on *Office and accounting machinery* (MSIC 30001) in compliance with Malaysia's Statistics Act 1965. As such there is no way of aggregating codes 30001 and 30002 to 4 digits to check for miscoding of trade codes in that sector at industry level. Apart from these few product lines (MSIC 29300, 30002, 31200, 32300), the results for Malaysia's apparent consumption (Table 5.8) are stable, especially for data from 2008 onwards.

Table 5.8 Malaysia's Apparent Consumption of E&E Goods

		US$ bn						
MSIC 5 digit	Description Manufacturing	2002	2008	2009	2010	2011	2012	2013
25206	Plastic injection moulded components	0.9	2.3	1.8	2.0	1.8	1.9	1.9
26100	Glass & glass products	0.8	0.8	0.7	0.9	1.0	0.9	0.9
26910	Non-structural non-refractory ceramic ware	0.05	0.1	0.1	0.1	0.1	0.1	0.1
29191	Air-conditioning, refrigerating & ventilating machinery	0.5	0.3	0.3	0.5	0.5	0.4	0.4
29220	Metal-forming machinery & machine tools		0.4	0.4	0.6	1.1	1.0	1.0
29290	Other special-purpose machinery n.e.c.		0.03	0.03	0.03	0.1	0.2	0.2
29300	Domestic appliances nec	0.03	0.3	0.2	0.2	0.5	0.5	0.7
30002	Computers & computer peripherals		1.4			0.7	1.3	0.5
31100	Electric motors, generators & transformer	2.5	1.8	1.5	1.9	1.6	1.5	2.1
31200	Electricity distribution & control apparatus		0.3	0.1		0.2	0.2	0.3
31301	Telecommunication cables & wires	0.03	0.2	0.1	0.2	0.4	0.4	0.4
27320	Other electronic & electric wires and cables	1.0	2.4	2.2	3.0	3.2	3.6	3.3
31400	Batteries & accumulators		0.3	0.1	0.0	0.3	0.4	0.1
31500	Lamps & lighting equip.		0.1	0.1	0.2	0.2	0.2	0.2
31900	Other electrical equip.nec		1.7	1.4	1.3	0.6	1.4	1.4
32101	Semi-conductor devices*	12.7	22.0	9.2	15.0	10.5	14.3	10.9
32102	Electronic valves & tubes & printed circuit boards*	7.2	9.2	7.3	8.7	8.1	7.6	7.7
32200	TV & radio transmitters & apparatus for line telephony & telegraphy	0.4	2.4	3.0	2.9	2.7	3.1	3.7
32300	TV & radio receivers sound/video record/reproduce		2.5	2.4	4.3	4.3	3.2	4.1
33110	Medical & surgical equipment orthopaedic	0.2	0.3	0.4	0.4	0.4	0.4	0.5
33120	Instruments & app. for measuring, checking, testing, navigating	0.2	0.6	0.6	1.0	0.7	0.7	0.8
33202	Photographic equipment	0.3	0.8	0.3	0.5	0.3	0.2	0.5

Note: Cells highlighted in grey mean figures are negative and have been dropped from the observation. Blank cells mean that the Department of Statistics does not provide production data for that year. Details on manual matching of MSIC code 32101 and 32102 are available in Appendix 5.6.
Source: Based on UNComtrade and Department of Statistics, Malaysia

Table 5.9 Rate of Import Penetration from China in Malaysia's E&E Consumption

MSIC 5 digit	Description Manufacturing	2002 %	2008 %	2009 %	2010 %	2011 %	2012 %	2013 %
25206	Plastic injection moulded components	0.02	0.04	0.05	0.1	0.2	0.3	0.2
26100	Glass & glass products	0.0	0.0	0.01	0.01	0.0	0.01	0.1
26910	Non-structural non-refractory ceramic ware	2.1	0.9	3.3	1.9	2.2	2.2	2.3
29191	Air-conditioning, refrigerating & ventilating mach.	1.7	28.9	13.5	12.7	17.0	27.9	24.6
29220	Metal-forming mach. & mach. Tools	0.0	4.5	6.3	4.5	3.2	3.2	3.5
29290	Other special-purpose machinery n.e.c.	0.0	0.0	0.7	0.6	0.1	0.4	0.2
29300	Domestic appliances n.e.c.	127.4	47.9	63.5	77.6	44.4	48.8	39.6
30002	Computers and computer peripherals.		268.9			402.3	216.0	584.5
31100	Electric motors, gen & transformer	10.5	31.1	29.0	31.1	41.1	49.1	38.3
31200	Electricity distribution. & control app.	0.0	141.7	261.4		343.0	418.5	217.0
31301	Telecommunication cables & wires	32.4	57.8	55.6	52.5	61.7	65.5	50.3
27320	Other E&E wires & cables	3.4	2.7	3.3	3.2	4.9	4.1	5.5
31400	Batteries & accumulators	0.0	98.4	234.8	283.8	53.2	32.8	92.8
31500	Lamps & lighting equipment	0.0	21.3	20.0	16.3	30.4	29.0	29.0
31900	Other electrical equipment n.e.c.	0.0	19.6	17.7	25.5	59.1	57.1	65.4
32101	Semi-conductor	4.6	6.1	24.7	13.4	22.9	31.2	48.8
32102	Electronic valves & tubes & PCB	3.2	5.3	4.2	4.1	5.4	7.0	7.8
32200	TV & radio transmitters & app. for line telephony & telegraphy	46.3	22.4	28.5	36.9	43.4	42.7	42.8
32300	TV & radio receivers sound or video recording/ reproducing app, & assoc. goods		36.4	32.5	31.3	34.3	42.2	33.4
33110	Medical & surgical equipment orthopaedic	0.1	2.2	1.0	2.4	2.4	4.2	4.7
33120	Inst. & app. for measuring, checking, testing, navigation	1.1	4.4	3.3	1.8	3.2	6.8	2.7
33202	Photographic equipment	12.3	16.4	17.3	4.4	9.4	14.1	7.8

Note: Cells highlighted in grey means results are in negatives and dropped from the observation. Cells left blank means there is no result for that particular year because the Department of Statistics of Malaysia does not have the production data for that year.
Source: Based on UNComtrade and Department of Statistics, Malaysia

Despite some weaknesses in Malaysia's data it is important to understand whether import penetration from China has increased or decreased over time. As shown in Table 5.9, data on *Semiconductor devices* (MSIC 32101) fluctuates as it is heavily exported and imported, meaning that the effect of international trade cannot be precisely segregated here because Malaysia's export data does not distinguish between re-exports and total exports. Results for *Batteries & accumulators* (MSIC 31400), and *Computers and computer peripherals* (MSIC 30002), *Domestic Appliances n.e.c.* (MSIC 29300), and *TV & radio receivers sound or video recording/ reproducing app, & assoc. goods* (MSIC 32300) are too unstable to form any conclusion on these products.

Nonetheless, the result of Malaysia's apparent consumption of E&E is increasing across all industries, especially *Air-conditioning, Refrigerating & Ventilating Machinery* (MSIC 29191) and *Electric motors, Generator & Transformers* (MSIC 31100). Table 5.9 above confirms that China's import penetration has been rising across all products associated with the MSIC industry codes except *Metal-forming Machine and Machining Tools* (MSIC 29220), which sees a falling share of China's imports in apparent consumption. Some apparent consumption results for industries such as *Air-conditioning and Refrigerating* (MSIC 29191) and *Lamp and Lighting Equipment* (MSIC 31500) illustrate the increasing penetration of Chinese import into the Malaysian domestic market. For example, China's share of imports of products grouped under *Air-conditioning and Refrigerating industries* (MSIC 29191), is only 1.7% of apparent consumption in 2002, but this rises to 24.6% of apparent consumption by 2013. This represents an average annual growth rate of 27.5% over 11 years, signalling the rise of China's electrical appliances industries such as air-conditioning since entering the WTO.

The rising import penetration of Chinese products has an effect on local players in Malaysia's electrical industry. Field interviews with Midea Scott & English Electronics, the local distributor of Midea China products, confirmed that they have been experiencing double-digit growth of their Midea air-conditioning products annually since 2008. The impact on Malaysian local firms is limited, as Malaysia's electrical appliances industry is not dominated by local players, although they exist, commanding a relatively low market share. The majority of the market share for household electrical products is commanded by Japanese and Korean MNCs. Therefore although China's imports into Malaysia's markets are steadily increasing they are mainly eroding the Korean and Japanese MNCs' market shares in products such as air-conditioners, TVs and audio equipment.

Despite field interviews suggesting that Korean and Japanese companies are mainly affected by China's import penetration, it also has an impact on local firms. Although competition from China was not cited as a direct cause of the selling-off of Malaysian air-conditioning manufacturing plants, a newspaper reports that OYL Berhad, the biggest Malaysian-owned air-conditioner manufacturer by volume, has sold up to Daikin of Japan and exited the industry because:

> Competition [has] led to the commoditisation of air-conditioning products, which resulted in a decline in profit margins, especially in residential air-conditioning products. OYL was faced with a choice of either having to focus as an equipment manufacturer or become a solutions-based group. We decided to drive its growth as a solutions-based group. (The Star Malaysia, 2006)

Two factors ease Malaysian industrialists' anxiety associated with the surge in Chinese imports. Firstly, China's imports to Malaysia's air-conditioning industry products, in the case of Midea China, is through a joint-venture model which means the local partner, Scott & English Electronics, benefits from some of the revenue stream from these imports.

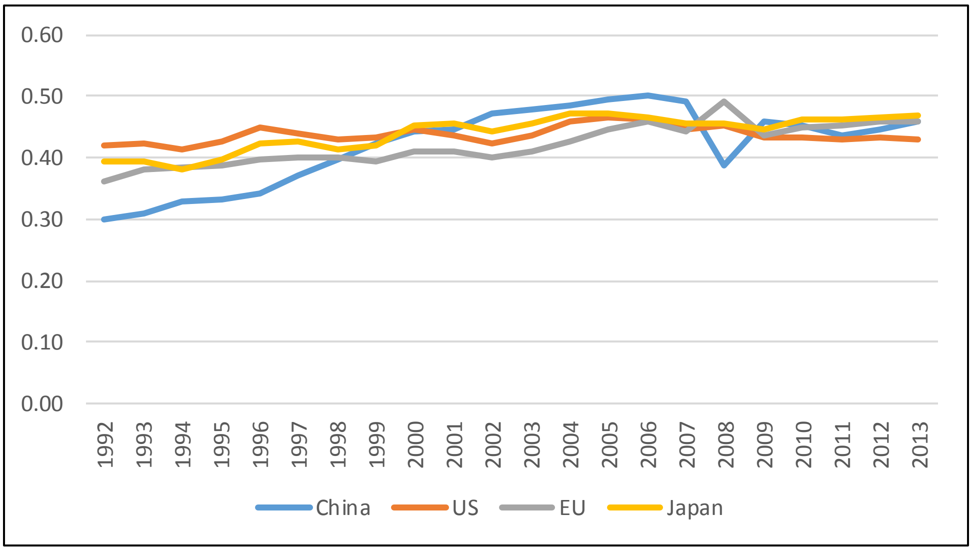
Secondly, a Malaysian-owned multinational company Pen1 (name changed) imports air-conditioners from China but sells them as a Malaysian brand. The limitation of analysis relying purely on import data manifests in Pen1's arrangement with a manufacturer in China. This Malaysian company controls its own value chain, including sales, marketing and brand name, and has outsourced manufacturing to China. However, Pen1's impact on the overall trade figure is limited, as it is not the market leader in household electrical products. Nevertheless, field interviews showed that the rate of import penetration based on import data is most likely overstated due special arrangements such as joint ventures between Malaysian and Chinese partners and because the outsourcing of manufacturing to China by Malaysian original brand owners (OBM) is not reflected in the trade data.

In short, China's import penetration of electrical goods has been rising in Malaysia's domestic market, signalling Chinese firms' increasing competitiveness in the electrical sector. Although the effects of the import penetration are limited as local Malaysian firms command a smaller market share than Japanese and Korean MNCs, they are nevertheless affected. However, the effects are mitigated through joint venture arrangements for China's entry into Malaysia's market and Malaysia's OBM tapping China's manufacturing facilities.

5.4 Comparing integration of exports and imports between Malaysia and China relative with other trade partners

As a form of forward-looking measure, this section measures the extent to which China's imports are integrated with Malaysia's exports compared to other major destination markets. The TCI gauges the complementarity of one country's trade with another relative to other countries by measuring how closely one country's exports match the other's imports. A close match with a high TCI score means that both countries have a better prospect for regional economic grouping and integration compared to where their trade structure is less compatible (Michaely, 1996). The TCI is calculated here for total trade and at the E&E level from 1992-2013, using 4-digit HS 1988/92 nomenclature.[74] The formula for the TCI is available in Section 3.1.3 of Chapter 3.

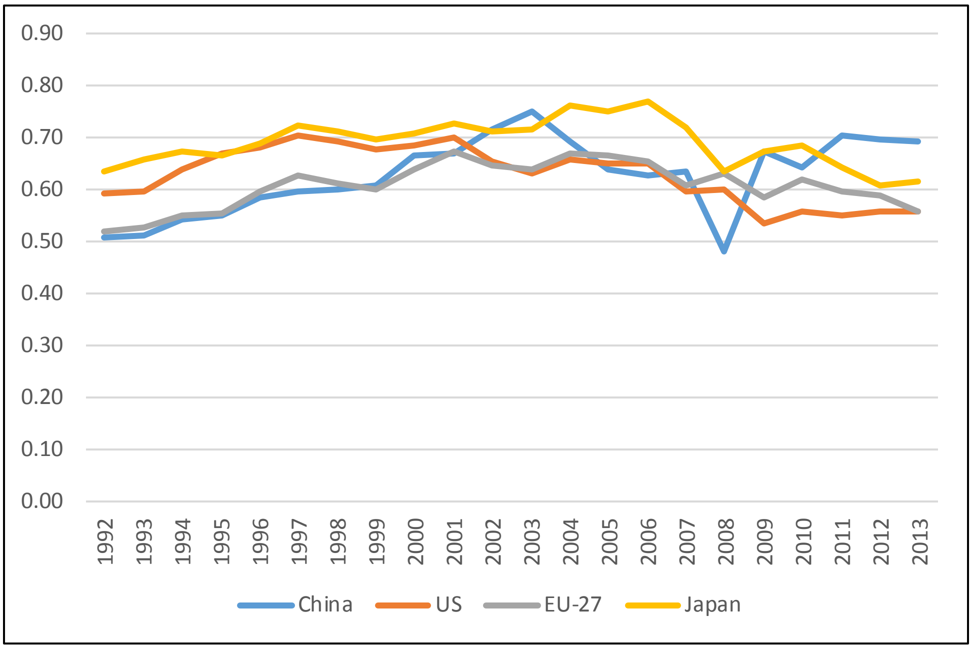
Figure 5.9 TCI Malaysia's Total Exports to Selected Countries



Source: Based on UNComtrade

Figure 5.10 TCI Malaysia's E&E exports with Selected Countries' E&E Imports

[74] Full list of HS code at 4 level digits at E&E Level is available in Appendix 3.3.



Source: Based on UNComtrade

The TCI reveals that Chinese imports are more closely matched with Malaysian exports in 2013 than they were in 1992 at both total export and E&E level. In Figure 5.9 and Figure 5.10, the TCI rises from 0.30 in 1992 to 0.46 for total exports in 2012 and from 0.51 in 1992 to 0.69 for E&E exports in 2013. At total exports level in Figure 5.9, China climbs from least compatible import market among the major markets for Malaysian exports in 1992 to the second most closely-matched import market in 2013 at 0.46, after Japan at 0.47.

For E&E exports, China rises from the least-matched import market in 1992 to the most closely-matched, surpassing all other markets (Figure 5.10). The TCI for the E&E industries of various countries in 1992-2013 shows that Malaysia-China TCI is increasing overall compared to the US, EU and Japan, which rose during the first decade (1992-2001), The TCI shows that the US and EU peaked in 2001, and Japan peaked in 2006, before declining. For example, for the US, the TCI for E&E was 0.59 in 1992, peaking at 0.70 in 2001 but dropping to 0.56 in 2013. In short, the compatibility of Malaysia's E&E exports with the US, EU, and Japanese imports have decreased, compensated by the overall increase in E&E export compatibility with Chinese imports.

Contrasting Figure 5.9 and Figure 5.10, the differences between the trends in the TCI for total exports compared to E&E stands out. This is due to the divergence in 2001-2007. The TCI for China's total exports rose continuously from 2001-2007 before declining in 2008 while the TCI for the E&E sector begin to descend in 2004-2008 before recovering and ascending again from 2009 onwards. The compatibility of China's imports with Malaysia's exports therefore diverges between total exports and the E&E sector.

E&E exports from Malaysia become less compatible with Chinese imports starting from 2004 onwards. This may be because Malaysia is withdrawing, resulting in the share of individual E&E products dropping as a share of total E&E exports, or China is importing less E&E products, or both. A preliminary check shows a decline in the computer goods and electrical sub-sectors in Malaysian exports as a major factor in the decline in the TCI from 2004 onwards. This is further explored in the next chapter, which discusses competition in the trade channel between Malaysia and China. Although the TCI for E&E with China recovers from 2009 onwards, its recovery is based on a surge in import demand, mainly for *Monolithic Digital Circuits* (HS8542) from China.

Overall, the TCI findings are consistent with the shifting importance of Malaysia's trading partners over time. The TCI for E&E also shows that Chinese imports are the closest match to Malaysia's exports from 2011 onwards with the US, EU and Japanese match to Malaysia's exports declining. Malaysia would be concern that the Malaysia-China TCI for E&E also notably falls from 2004-2008 but recovers again from 2009 onwards. Therefore while Chinese imports of Malaysia's E&E exports were more integrated in the immediate years China joins WTO in 2001, compatibility between Chinese imports and Malaysian exports in finished goods sub-sectors such as the computer industry and household electrical industry declined during 2004-2008, and this is captured by the TCI.[75]

5.5 Conclusion

This chapter has shown that China has both positive as well as negative effects on Malaysia through their bilateral trade. Their total bilateral trade volume rose rapidly in 1992-2013. China is indeed Malaysia's number-one trading partner, and trade data affirms the E&E sector (in both HS code Chapter 84 and 85) as the top sector traded between Malaysia and China. The preliminary trade analysis lends credence to the observation by Athukorala and Kophaiboon (2014) that the East Asian regional production network is indeed benefiting countries such as Malaysia.

While Malaysia's bilateral trade balance with China is reasonably balanced, China is increasingly exporting consumer goods to Malaysia, especially since joining the WTO in 2001. This coupled with fuel and lubricants being top three items exported from Malaysia to China, the rise of commodity based exports raises the fear of the primarisation of Malaysia's economy.

The volume of E&E exports and imports steadily increased during 1992-2013, suggesting a complementary relationship between Malaysia and China. Moreover, based on types of goods exchanged, computer goods and

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[75] Computer manufacturer Dell shifted its desktop PC manufacturing from Penang to Xiamen, China. Top three items measured by decline in TCI points in 2004-2007 are *Automatic data processing machines* (computers) *(HS8471),* P*arts, accessories, except covers, for office machine (HS8473)*, and *Radio and TV transmitters, television cameras (HS8525)*. The period 2004-2007 is taken rather than 2004-2008 because 2008 saw the beginning of the global financial crisis.

parts and components dominate the bilateral trade. While this is consistent with East Asian production network literature (Athukorala and Kophaiboon, 2014), some of the results reported in this chapter also diverge.

The divergence includes, first, the fact that Malaysia's E&E trade balance widens notably after China joined the WTO in 2001, with the volume of parts and components exported unable to offset the deficit in total E&E level due to the steady increase in imports of E&E final goods, and the E&E trade balance slips back into deficit from 2012 onwards after a brief interval with a trade surplus in 2009-2011. Nevertheless, the deficit in E&E parts and components in the years immediately after China joined the WTO can reflect global production arrangements, with China producing less sophisticated parts and components and Malaysia importing them for production purposes. This is discussed in Section 6.5 in the next chapter, which considers the colour TV market.

Secondly, the results of the E&E trade disaggregated by sophistication reflect the shifting of the functionality of China's export structure within the E&E regional production network. China is showing signs of moving from being just a centre for the assembly of final goods for the region to manufacturing higher-value parts and components, as shown in the data on its exports to Malaysia. China has stepped into the product space of Malaysia's specialisation, notably in the semiconductor industry, since 2008, although Malaysia still exports more sophisticated E&E goods to and receives less sophisticated E&E goods from China.

Based on the import penetration analysis, China's E&E goods import penetration of Malaysian market has increased for the majority of industry categories, especially in electrical appliances such as lighting products and air-conditioners from 2008 onwards. Field interviews, however, suggested that China's effect is mitigated by its mode of entry: i.e. as a joint venture with a local company or when Malaysian-owned companies utilise Chinese electrical goods production capacity to sell under a Malaysian brand name.

The TCI results suggest that the bilateral trade is complementary between Malaysia and China. China's import structure is increasingly compatible with Malaysia's export structure compared to other traditional partners, both at the total trade and the E&E level. However, Malaysia's exports of computer goods and decline in electrical good are captured by lower TCI scores in 2004-2008. Finally, Malaysia's TCI with China at the E&E level recovers from 2009 onwards, mainly driven by China's demand for IC imports.

Overall, the bilateral trade between Malaysia and China in the E&E sector has been positive for both countries. Malaysia fares better in parts and components, and specifically in the semiconductor industry. On the other hand, its household electrical industry faces the competitive force of China's rise as it increasingly imports consumer goods from China. After 2008 China stepped into product space previously occupied by Malaysian semiconductors, notwithstanding that Malaysia currently still sends more high-value semiconductor to China than it receives from it. The next chapter investigates whether the relationship between the exports from both countries is in competitive or mutual expansion.

6.0 How much can trade data tell us about competition for Malaysian E&E from China at Destination Markets?

Based on the Asian Drivers framework, export competition in third markets between Malaysia and China is an indirect effect of China's rise. This chapter examines whether China's rise has been complementary to, or competes with, Malaysia's E&E sector in the trade channel by comparing the share of E&E imports from Malaysia with the share of E&E imports from China at their destination markets (see Figure 3.1 in p.46).

The main research question here is to what extent Chinese and Malaysian E&E exports compete in their destination markets. The second main research question is whether Malaysia's E&E imports structure, disaggregated by level of sophistication, shows evidence of being upgraded? For this second question, a competitiveness analysis, disaggregated by sophistication, reveals whether Malaysia displays upgrading in response to China's competition for destination markets for its exports, and relates to a key question in the GPN literature: whether the challenge posed by China induces Malaysia to upgrade its E&E value chain (Ernst (2004).

Based on the main research questions, the following sub-questions guide the discussion in this section:

- Is Malaysia losing market share to China, and if so, in which types of product at the destination markets?
- What proportion of E&E imports from Malaysia, disaggregated by level of sophistication, faces competition from China at their destination markets, and what proportion is in a relationship of mutual expansion with Chinese imports to their destination markets?
- Does the disaggregation of exports of E&E by sophistication reveal signs of upgrading on the part of Malaysia's E&E industry?

- Does the disaggregation of exports of E&E by sophistication reveal signs of upgrading on the part of Malaysia's E&E industry?
- What do the E&E trade data at destination markets analysed by types of goods reveal about Malaysia's changing role within the GVC/GPN production network?

This chapter presents the findings from the competitiveness analysis based on the movement of Malaysia's share of E&E product imports at the destination markets, namely the US, EU and Japan, in relation to China's using mirror-trade data.[76] Secondly, it examines whether the structure of imports from Malaysia disaggregated by sophistication shows that Malaysia's exports to destination markets have been upgraded. The chapter discusses the results from the most sophisticated goods to the least sophisticated segment of E&E products.

The import share calculations are limited firstly by the national trade statistics that capture the value based on gross output of the exports. The trade data could not capture the associated value-added at each stage of the manufacturing process, which is important as E&E is an industry that is highly fragmented across borders. This means that when evaluating the impact of China on Malaysia's E&E industry, China's sophistication in the exports basket can be overstated if it captures a small share of value-added in a high-technology export item. Secondly, as with the competitiveness analysis associated with the Lall and Albaladejo (2004) framework, this chapter is unable to claim causality with respect to China's effect on the rise or fall of Malaysia's import share. Nevertheless, competitiveness

[76] In this study 'EU' refers to EU-27 although currently the EU has 28 members, since the latest member, Croatia joined in 2014. Based on the World Bank WITS manual, the UNCOMTRADE database only provides data based on EU-27 for the EU category. Mirror trade data using the US, EU and Japan as reporter in the data. According to the World Bank WITS manual, countries with better statistical service such as OECD countries provide better-quality data.

analysis provides detailed results of the relative movement of product shares compared to highly aggregated 'reductionist' results.

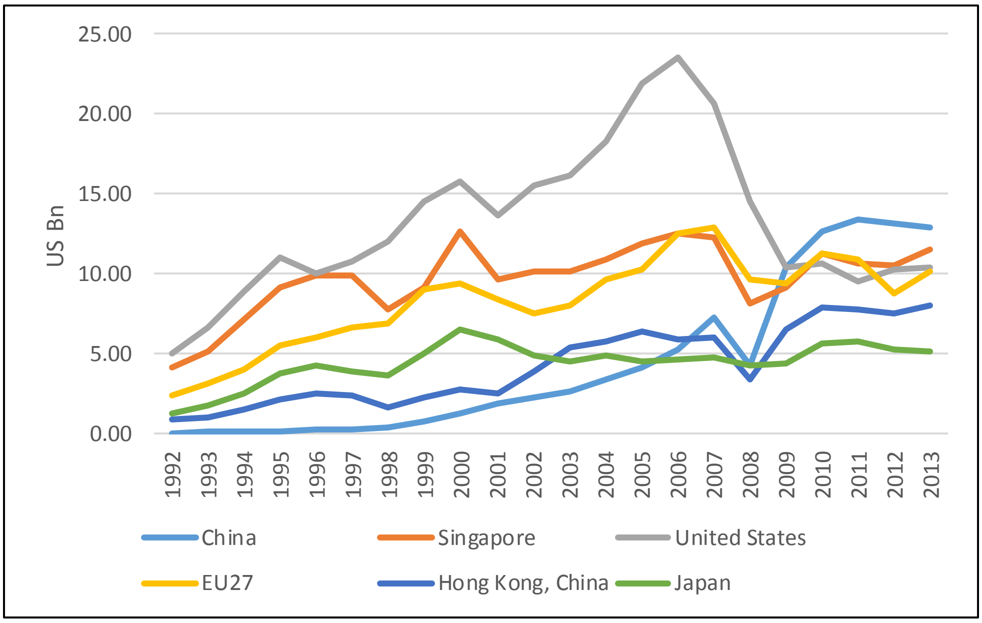
Moreover, a competitive analysis at the destination markets is more reflective of real-world interactions than an analysis of total exports, and further improves Lall and Albaladejo (2004)'s World Market Share (WMS) analysis. This chapter also validates the findings from the competitiveness analysis at destination markets through field interviews and adds layers of perspective to the findings where applicable.

The chapter is structured in the following manner: first the volume of E&E product imports from Malaysia and China and the level of threat to E&E imports from Malaysia posed by Chinese imports using Jenkins' index of competitive threat (ICT) are presented, and this is followed by a competitive analysis of E&E imports from Malaysia and China into the US, EU and Japanese markets in 1992-2002 and 2002-2012. The competitive analyses for each destination include the degree to which China competes to export the same E&E products as Malaysia, competitive analysis disaggregated by level of sophistication to see if imports from Malaysia display upgrading, and type of goods analysis to examine the shifting role of Malaysia in the regional production network by comparing Malaysia and China's import shares under BEC classification. Subsequently, qualitative field interviews further inform the impact of China on Malaysian players in specific markets and Malaysia's response to China's rise. The chapter concludes that the relationship between China and Malaysia's E&E imports differs according to the destination markets, and that Malaysia has upgraded its imports structure.

6.1 Volumes of Malaysia and China's E&E Product Export and Import in US, EU, and Japan Markets and Level of Threat to Malaysia's E&E

This section provides descriptive data and a preliminary analysis of China's threat to Malaysia's E&E exports based on ICT index. The export data in Figure 6.1 reveals major destination markets for Malaysia's E&E exports. Malaysia's most important E&E exports destinations by value are the US followed by the EU and Japan. Malaysia's exports to China have been discussed in Chapter 5 regarding their bilateral trade, while Singapore and Hong Kong are predominantly entrepôt destinations and are therefore not included in the analysis.

Figure 6.1 Major Destinations of Malaysia's E&E Exports



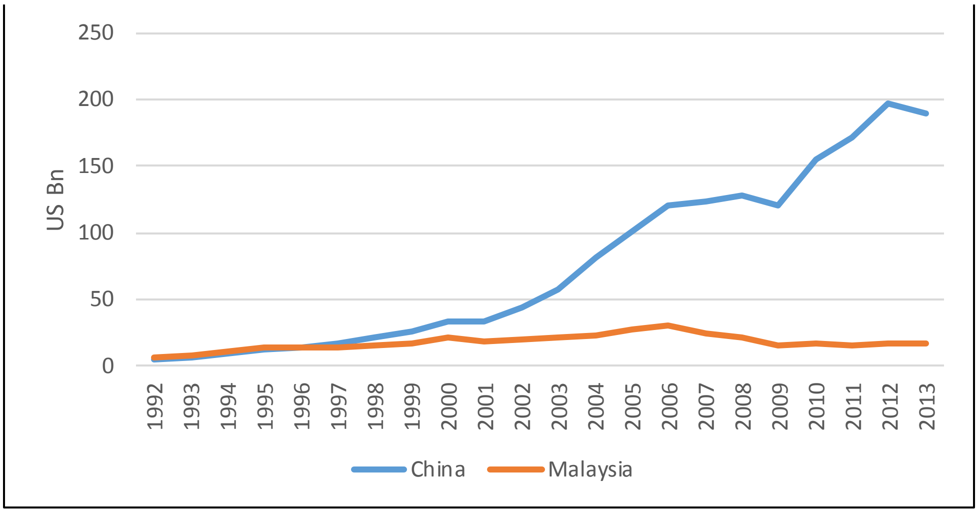
Source: UNComtrade

From this point onwards in this chapter, I switch over to import data at destination markets. Figure 6.2,

Figure 6.4, Figure 6.6 and presents descriptive statistics on E&E imports from Malaysia and China into the US, EU, and Japan market as below. To put things into perspective, the US market is the biggest destination market by value, followed by the EU and finally, Japan. E&E imports from Malaysia into the US market were worth US$17.5 billion, into the EU market were worth US$14.0 billion and into the Japanese market were worth US$5.1 billion in 2013.

Collectively, these three markets represent 28.6% of total world imports of E&E from Malaysia in 2013, a drop from 48.4% in 2002 that is attributed to the rise in China's imports of Malaysia E&E products.[77]

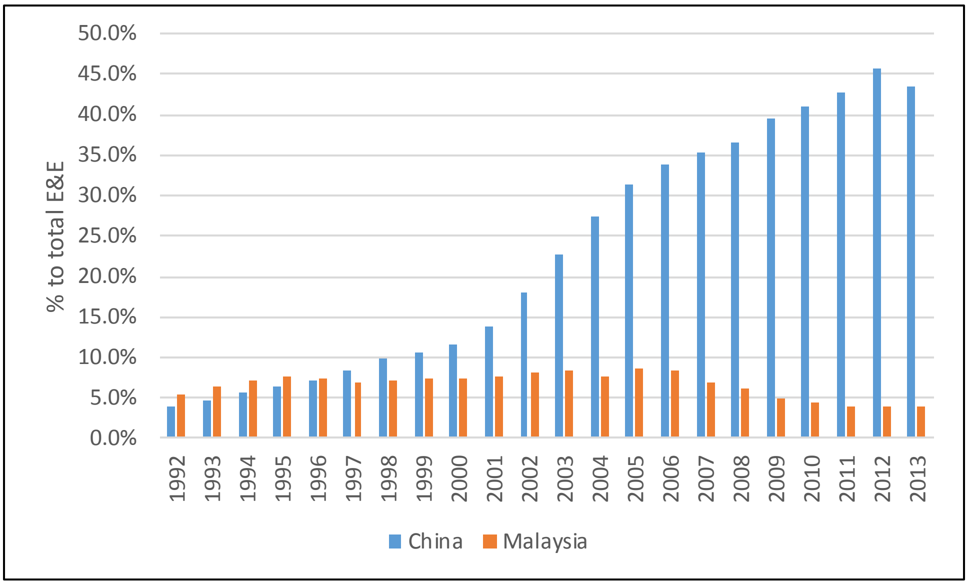
Figure 6.2 US Total Imports of Malaysian and Chinese E&E



Source: UNComtrade

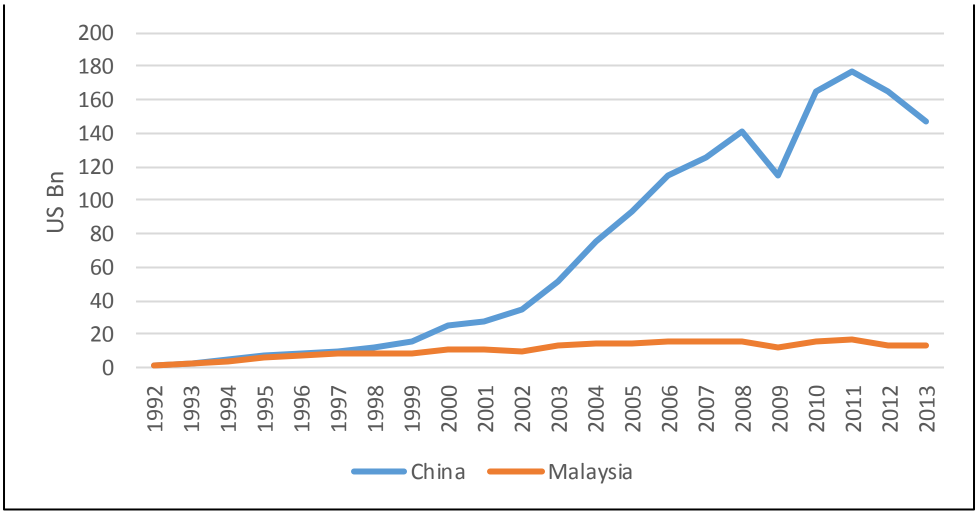
Figure 6.3 Malaysia and China Market Share in the US E&E Imports

[77] China's share of total world E&E imports into Malaysia grew from 7.7% in 2002 to 30.7% in 2013.



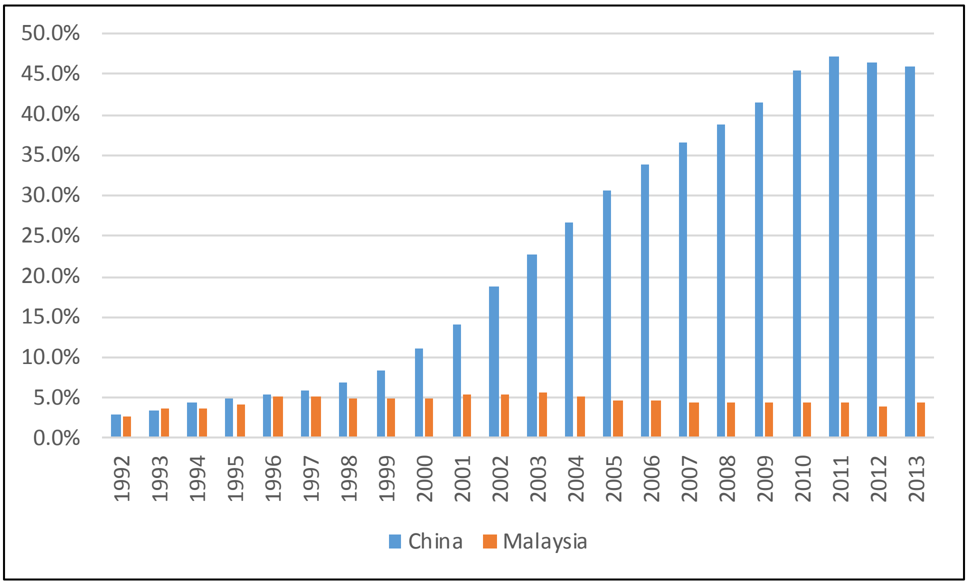
Source: UNComtrade

Figure 6.4 EU Imports of E&E Products from Malaysia and China



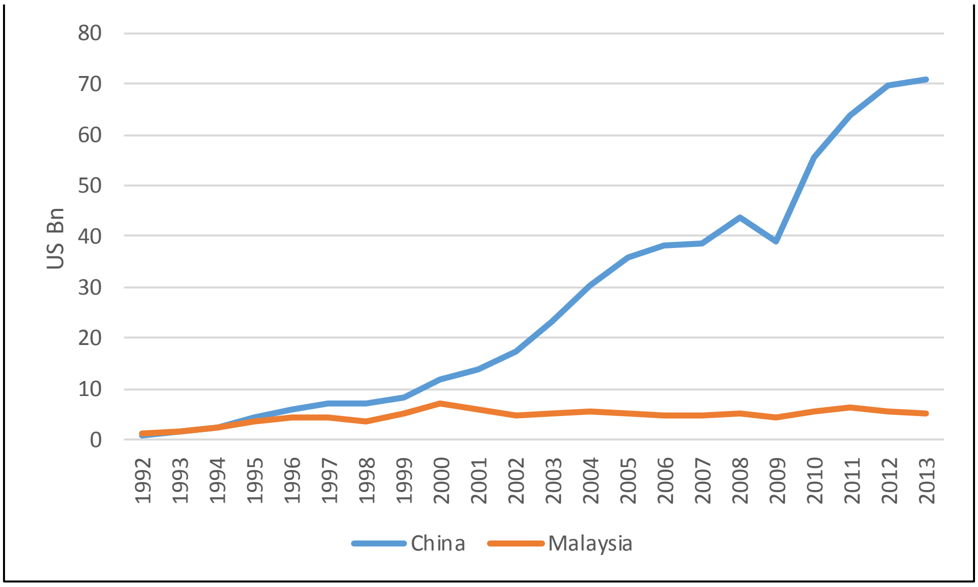
Source: UNComtrade

Figure 6.5 Malaysia and China market share of E&E imports to the EU



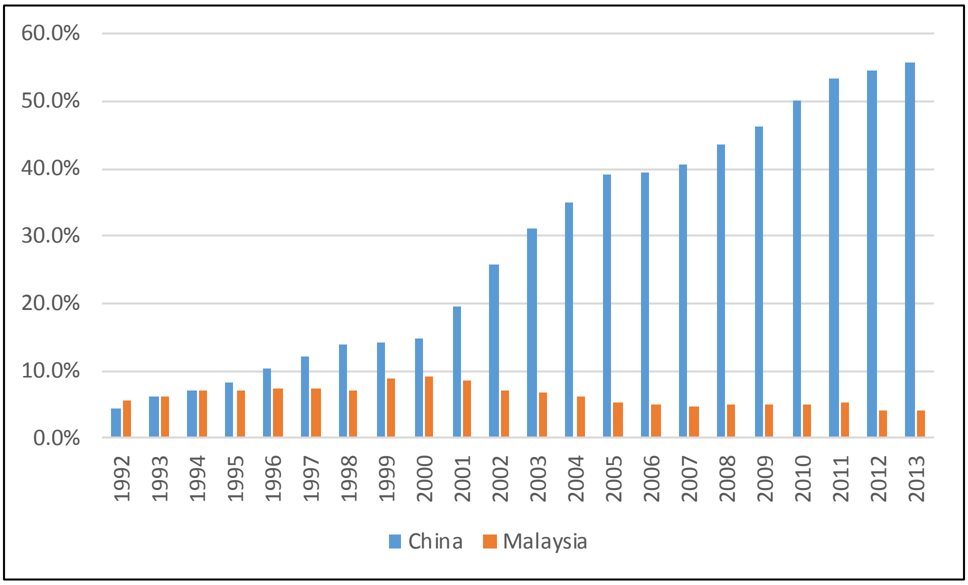
Source: UNComtrade

Figure 6.6 Japan Imports of E&E Products from Malaysia and China



Source: UNComtrade

Figure 6.7 Malaysia and China Market Share in Japan E&E Imports



Source: UNComtrade

Figure 6.2,

Figure 6.4 and Figure 6.6 show the common trends with the divergence of the value of Malaysia and China's imports to the major destination markets. Imports from China into the destination markets grew rapidly, while Malaysia's growth, especially from 2001 onwards, is relatively flat. Moreover, imports of E&E products from Malaysia clearly decline in the US market from 2006 onwards from a peak of US$29.8 billion in 2006 to US$15.7 billion in 2009, but gradually recover to US$17.5 billion in 2013. Imports of E&E from Malaysia to the EU are maintained at US$12.0-16.0 billion per year in 2006 -2013. Finally, Malaysian imports in Japan also declined from a peak in 2000 of US$ 7.2 billion to US$4.2 billion, before recovering to US$5.1 billion in 2013.

Based on market share at the destination markets, imports from Malaysia are clearly declining in the US and Japan, while in the EU they are holding their ground against rising imports from China in 1992-2013, as shown in Figure 6.3, Figure 6.5 and Figure 6.7. Malaysia and China's market share of total E&E imports into the US (Figure 6.3) are 5.4% and 3.9% respectively in 1992. In 1997, China's market share of total E&E imports in the US market

(8.3%), overtook Malaysia's (6.9%) for the first time. China continues its upward trend, while Malaysia peaks at 8.6% of total E&E imports in 2005 after gaining market share during the initial years of China joining the WTO in 2001, and thereafter declines to 4.0% while China shares reaches 43.6% in 2013.

In the EU, imports from Malaysia comprise 2.7% of total E&E imports 1992 against China's 2.8%. Imports from China overtook those from Malaysia in 1994, at 4.3% and 3.6% of total imports respectively. Imports from Malaysia peaked in 2003 at 5.7% before going into a general downtrend to 4.3% of total imports into the EU market in 2013. Conversely, China's market share rose from 14.2% to stabilise at more than 40.0% of total E&E imports into the EU after 2009.

Malaysia's market share of the Japanese market is 5.6% and China's 4.4% in 1992. Malaysia's market share peaks in 2000 at 9.0% of total Japanese E&E imports before starting in long-term decline to 4.0% in 2013. Conversely, China is on the uptrend in 1992-2013 from 14.8% in 2000 to 55.6% of total Japanese E&E imports in 2013.

Generally E&E imports from Malaysia into the destination markets increases its market share slightly in the initial years after China joins the WTO, except for Japan, which peaks in 2000 but declines thereafter. China on the other hand increases its market share in destination markets by no less than 40.0% of the E&E imports in each market. Malaysia's long-term decline suggests that the relationship between imports from Malaysia and China is competitive, Malaysia's loss of market share in the EU is the smallest in terms of magnitude.

Based on the descriptive data, the value of Malaysian E&E imports into the US and Japan is going in the opposite directions to its E&E world exports as shown in Chapter 4. Contrasting Figure 4.1 (p.67) with Figure 6.2 showing that Malaysia's total world exports of E&E products continues to grow even in 2003-2013 from US$57.0 billion to US$77.0 billion. Conversely, the value of its imports of E&E products to the US decline from US$21.1 billion in 2000 to US$17.5 billion in 2013 and in Japan from US$7.2 billion in 2000 to US$5.1 billion in 2013. This opposing trend between Malaysia's world E&E exports and imports from Malaysia in destination markets is partly explained by a worldwide shift of E&E production to China, as explained in Chapter 4.

Table 6.1 below compares imports from Malaysia and China into specific markets and shows that China's exports are growing exponentially while Malaysia's growth slows after 2003. For example the US market, as the biggest in the three main destinations, sees the average annual growth rate of Malaysian E&E imports from 2003-2013 dropping to -1.9% from a robust 12.8% growth per year in 1992-2002 while conversely, China records double-digit growth every year in both periods.

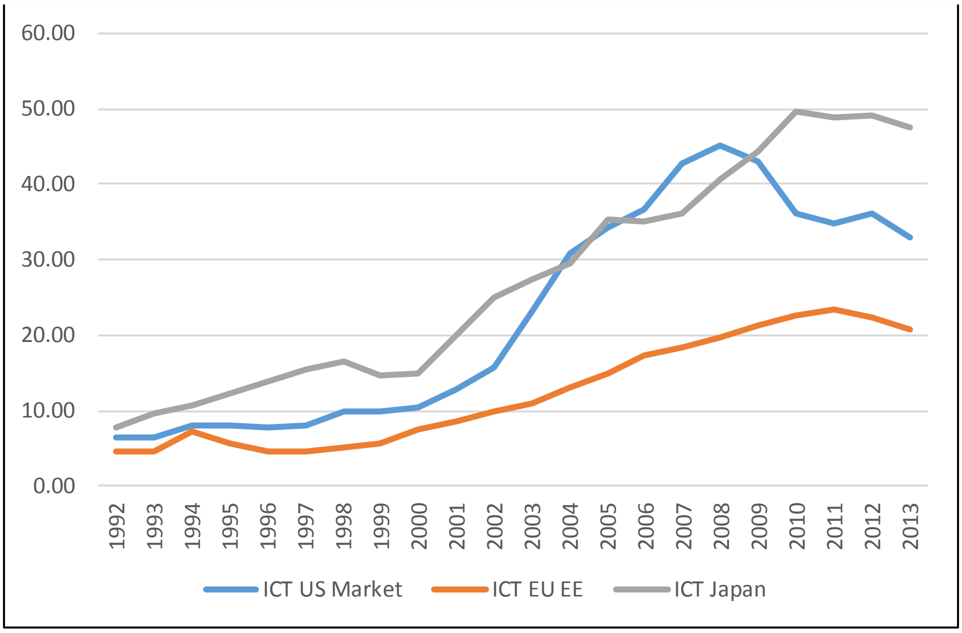
Table 6.1 Growth Rate of Imports from Malaysia and China to Destination Markets

		CAGR (%)		
Destination Market	Import from	1992-2002	2003-2013	1992-2013
US	China	26.3	12.7	19.9
	Malaysia	12.8	-1.9	5.3
EU	China	36.2	11.1	24.1
	Malaysia	21.1	0.8	11.2
Japan	China	34.9	11.9	23.4
	Malaysia	15.5	0.4	7.6

Source: Based on UNComtrade data

Next, the ICT measures the level of the threat of China's E&E imports to those from Malaysia at the market destinations.

Figure 6.8 China Exports Threat on Malaysian E&E Imports at Destination Markets



Source: Based on UNComtrade data

The result of the ICT illustrated in Figure 6.8 shows that the level of threat has increased for Malaysian E&E imports to all destination markets. The highest increase is recorded in Japan, followed by the US and then the EU. At all three destinations the ICT increases were driven mainly by the growth of China's share of total imports to the destination markets rather than as a result of a rise in Malaysia's E&E exports. This higher imports share of China shows China is gaining exports competitiveness in these markets. From 2008 onwards the ICT for the US, the epicentre of the global financial crisis, exhibits a downward trend due to a drop in the volume of household electrical goods items imported from China. As a result, China's share of US imports at product level of durables declined, as indicated by a steep drop from the highest ICT at 45.2 in 2008 to 36.1 in 2010.[78] China's export threat to E&E imports from Malaysia increases in all three destination market in 1992-2013.

[78] Interestingly, HS841720, the HS code for tablets such as the iPad, increases during the same period for Chinese imports to the US while Malaysia's share of US imports of HS841720 declined significantly during the same period.

Table 6.2 Share of E&E sector in Total Imports from Malaysia by Destination Market

		2002		2012	
Destination Markets	No. of Product	US$ bn	% of Imports	US$ bn	% of Imports
US	338	20.0	82.7	16.5	64.0
EU-27	338	10.1	67.4	14.0	52.7
Japan	338	4.7	41.8	5.4	17.3

Source: Based on UNComtrade data

Table 6.2 shows a decline in Malaysia's share of total E&E sector imports to all three markets. Its imports to the US declined from 82.7% in 2002 to 64.0% in 2012, those to the EU fell from 67.4% in 2002 to 52.7% in 2012, and most drastically, imports to Japan dropped from 41.8% in 2002 to 17.3% in 2012. The decline of E&E as a share of total imports from Malaysia to the destination markets, coupled with the rising threat from the ICT index, does not augur well for Malaysia's E&E export competitiveness, but this is subject to further to competitive analysis below.

The rest of the chapter discusses the findings of the competitive analysis for the US, EU and Japan markets. For each market, the sequence is the main competitive analysis, reverse tracking of the competitive analysis to show changes across categories from 2002 to 2012, the competitive analysis disaggregated by sophistication and then by type of goods. Finally, a separate section discusses Malaysia's response to the loss of its durables exports to the US and EU.

6.2 Competitive Analysis: The US Market

This section finds E&E imports from Malaysia in the US market face competition from China, which induces Malaysia to offer more sophisticated imports to the US. For regional production network roles, comparing 1992-2002 with 2002-2012 shows that China has replaced Malaysia as the supplier of finished goods such as computers and electrical goods, including televisions. Malaysia is increasingly specialising in more sophisticated parts and accessories imports such as ICs. The structure of US imports from Malaysia is upgrading over time, based on a higher EXPY" index than China's EXPY" and disaggregation of the import structure by PRODY index quartiles in this section.

China is competitive towards Malaysian E&E imports in the US market, as shown in Table 6.3, below.[79] For example, the 85.2% of total E&E imports from Malaysia to the US categorised under Mutual Expansion (i.e. both Malaysia and China's shares of US imports rising together) in 2002 falls to 23.6% in 2012. Conversely, in the Competitive category (Malaysia's share of US imports falling while China's rises) increases sharply from 14.8% of total E&E imports in 2002 to 75.0% in 2012. A miniscule share of E&E imports under the Reverse Category (Malaysia's share of US imports rising, China's falling) shows that faced with Chinese competition, Malaysia lacks winning products.

Table 6.3 Competitiveness Analysis of E&E in the US market

	2002			2012			Difference		
Category	No. of	US$	% of	No. of	US$	% of	No. of	US$	% of

[79] Results tables in Sections 6.2, 6.3 and 6.4, total number of E&E products is 336 rather than 338, due to manual adjustment of 4 HS codes to 2 HS codes with the combination of digital and non-digital ICs (HS 854211 + HS 854219). The second combination is *Network switchboards and other telegraphic* (HS 851730 + HS 851782). Codes are combined because of the unusual data movement in the series, with values in HS 854219 growing exponentially in 2012, while the HS 854211 contracts severely and similarly in the case of HS 851730 and HS 851782.

	Prod	bn	E&E	Prod	bn	E&E	Prod	bn	E&E
Competitive	81	3.0	14.8	127	12.4	75.0	46	9.5	60.2
M. Expansion	154	17.0	85.2	106	3.9	23.6	-48	-13.1	-61.6
R. Competition	8	0.0	0.0	6	0.2	1.4	-2	0.2	1.4
M. Withdrawal	9	0.0	0.0	21	0.0	0.0	12	0.0	0.0
N.A.	84	0.0	0.0	76	0.0	0.0	-8	0.0	0.0
Total	336	20.0	100.0	336	16.5	100.0	-	-3.4	-

Note: M.=Mutual, R.=Reverse
Source: Based on UNComtrade data

Next, the competitiveness analysis category such as Competitive, Mutual Expansion and Reverse Category of E&E imports from Malaysia at the destination market in 2012 is matched backwards to its various categories in 2002. This gives a sense of the relative size of the movement across categories of the same goods over time.

Table 6.4 Distribution of Competitive Analysis Outcomes in 2012 to 2002 according to E&E Product Codes (US Market)

Results in 2002	No. of Products	US$ bn	% of E&E	Results in 2012	No. of Products	US$ bn	% of E&E
Competitive	32	2.37	11.8	Competitive	127	12.4	75.0
M. Expansion	88	16.21	81.1				
R. Competition	5	0.00	0.0				
M. Withdrawal	2	0.00	0.0				
Total	127	18.57	93.0				
Competitive	30	0.5	2.3	M. Expansion	106	3.9	23.6
M. Expansion	52	0.4	2.2				
R. Competition	2	0.0	0.0				
M. Withdrawal	1	0.0	0.0				
N.A.	21	0.0	0.0				
	106	0.9	4.5				
Competitive	1	0.0	0.0	R. Competition	6	0.2	1.4
M. Expansion	3	0.3	1.3				
N.A.	2	0.0	0.0				
	6	0.3	1.3				

Competitive	12	0.12	0.6	M. Withdrawal	21	0.0	0.0
M. Expansion	9	0.10	0.5				
	21	0.22	1.1				
Competitive	6	0.0	0.0	N.A.	76	0.0	0.0
No Threat	2	0.0	0.1				
R. Competition	1	0.0	0.0				
M. Withdrawal	6	0.0	0.0				
N.A.	61	0.0	0.0				
	76	0.0	0.1				
Grand Total	336	20.0	100.0	Grand Total	336	16.5	100.0

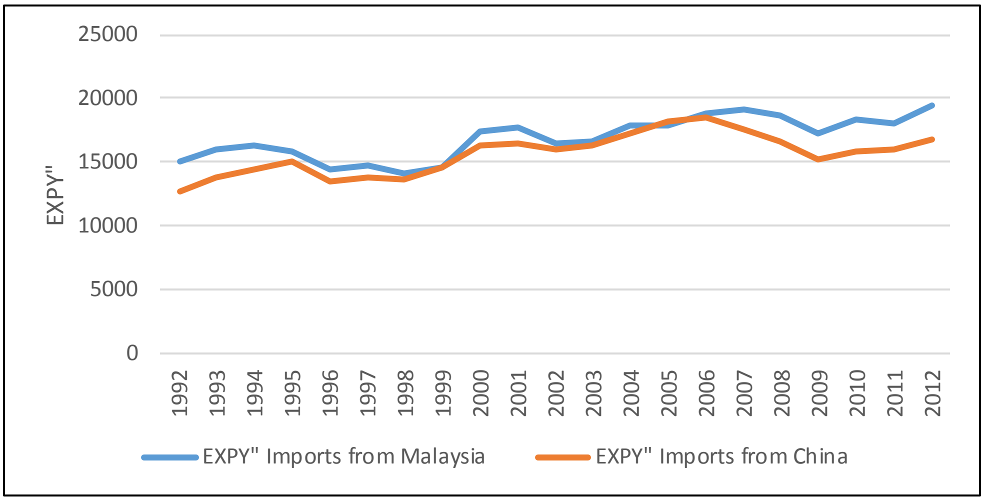
Note: M.=Mutual, R.=Reverse
Source: Own calculations based on UNComtrade data

The overall relationship between Malaysian and Chinese E&E in the US market is overwhelmingly competitive, based on the trade data. Table 6.4 above, shows that 93.0% of Malaysian E&E imported to the US in 2002 face competition from Chinese E&E imports in 2012. The computer industry and computer related-parts are declining in the face of China's rising imports. In 2002, US imports from Malaysia of *Digital computers with cpu and input-output units* (HS841720) are worth US$ 2.9 billion, but by 2012 they are worth only US$0.3 billion. Interestingly, in the US market even *Integrated Circuits* (HS 854211 and HS 854219) have switched from the Mutual Expansion category in 2002 to Competitive in 2012. Conversely, Malaysia's Mutual Expansion relationship with Chinese exports is largely based on its exports to the US of *Photosensitive semiconductor devices* (HS 854140) growing from US$0.1 billion in 2002 to US$1.8 billion in 2012. In the Reverse Competition category, Malaysia lacks winning products to withstand the competition from China. Detailed product-level tables are available in Appendix 6.1.

Next, I examine whether the structure of imports from Malaysia to the US displays signs of upgrading of the E&E value chain over time. The EXPY" index is used to compare the sophistication of Malaysia and China's imports into the US, followed by a detailed analysis of competitive analysis based on PRODY index quartiles.

Based on the EXPY" index, the sophistication of Malaysian E&E imports is generally greater than that of China's. The EXPY" index is the sum of the weighted PRODY index of E&E imports from a particular country to the destination market. It thus provides an indicator of the level of productivity associated with that country's exports to the destination market.

Figure 6.9 Imports from Malaysia and China EXPY" in the US Market



Source: Based on UNComtrade data

The EXPY" index shows that the sophistication of Malaysian imports in the US market is higher than that of imports from China, except in 2005, when China's EXPY" index is slightly higher than Malaysia's (see Figure 6.9 above). The EXPY" of 17921.0 for imports from Malaysia in 2005 is slightly below China's at 18231.9, the surge in China's EXPY" in 2005 mainly caused by gains from its *colour televisions* (HS 852520) exports and *audio recording without reproduction* (HS 852090). However, after 2006 Malaysia clearly increases the sophistication of its E&E imports in the US market compared to China.

Next, the competitive analysis is disaggregated by level of sophistication with each E&E product ranked using the PRODY index, which is divided into four quartiles. The first quartile contains the most sophisticated products and the fourth, the least sophisticated products. Products listed in each specific quartile are summed up to show the market share of total E&E imports at each level of sophistication.

Table 6.5 Competitive Analysis of US E&E Imports from Malaysia and China based on Sophistication

	2002			2012		
	No. of prod.	% of total exports	% of E&E	No. of prod.	% of total exports	% of E&E
1st Quartile						
Competitive	12	5.0	6.0	27	18.7	29.3
M. Expansion	41	4.4	5.3	35	9.5	14.9
R. Competition	2	0.0	0.0	1	0.0	0.1
M. Withdrawal	3	0.0	0.0	4	0.0	0.0
N.A.	26	0.0	0.0	17	0.0	0.0
Total	84	9.4	11.4	84	28.3	44.2
2nd Quartile						
Competitive	15	0.7	0.8	35	20.3	31.8
M. Expansion	46	26.6	32.2	31	0.9	1.4
R. Competition	4	0.0	0.0	2	0.0	0.0
M. Withdrawal	1	0.0	0.0	2	0.0	0.0
N.A.	18	0.0	0.0	14	0.0	0.0
Total	84	27.3	33.0	84	21.3	33.3
3rd Quartile						
Competitive	27	4.8	5.9	36	7.9	12.3
M. Expansion	37	31.4	37.9	25	3.9	6.1
R. Competition	2	0.0	0.0	1	0.0	0.0
M. Withdrawal	0	0.0	0.0	7	0.0	0.0
N.A.	18	0.0	0.0	15	0.0	0.0
Total	84	36.2	43.8	84	11.8	18.5
4th Quartile						
Competitive	27	1.7	2.1	28	1.0	1.6
M. Expansion	30	8.1	9.8	15	0.7	1.1
R. Competition	0	0.0	0.0	2	0.8	1.3
M. Withdrawal	5	0.0	0.0	9	0.0	0.0
N.A.	22	0.0	0.0	30	0.0	0.0
Total	84	9.8	11.9	84	2.6	4.0
Grand Total	336	82.7	100.0	336	64.0	100.0

Note: M.=Mutual, R.=Reverse
Source: Based on UNComtrade data

Overall, the drop in the share of least sophisticated goods in total E&E imports at destination markets, coupled with a rise in the contribution of the most sophisticated goods in 2012 compared to 2002, confirms Malaysia has upgraded its exports to the US market.[80] As shown in Table 6.5 above, its share of total E&E imports in the first quartile jump from 11.4% in 2002 to 44.2% in 2012 for the US market. [81] In the second quartile, the share remains roughly the same from 2002 to 2012, at 33.0%. The first and second quartiles collectively represent 77.5% of total imports in 2012. Conversely, the share of US imports in the third and fourth quartiles falls from 2002 to 2012, with a contraction in the third quartile from 43.8% in 2002 to 18.5%.

In the US market, competition against Malaysia's imports is mostly concentrated in the first and second quartiles by 2012. In 2012, the 29.3% of total E&E imports from Malaysia in the first quartile and the 31.8% in the second are losing their market share compared to China's rising imports share in the US market. The competition in the second quartile is mainly over *telegraphic apparatus and products* (combining HS 851730 and HS 851782), while competition in the second quartile is in *IC* (HS 854211 and HS 854219). The situation in 2002 is different, with the majority of imports from Malaysia in mutual expansion with E&E imports from China in the second quartile at 32.2% of total E&E imports and 37.9% in the third quartile.

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[80] In absolute values, the value of Malaysian E&E imports dropped from US$20.0 billion in 2002 to US$16.6 billion in 2012.

[81] While the most sophisticated quartile's share of total Malaysian imports, especially into the US, rise from 13.8% to 48.9%, the volume of exports declines from US$20.0 billion in 2002 to US$16.6 in 2012. However, overall, in absolute numbers the value of imports from Malaysia in Quartile 1 rises in the US market, thus it is still considered an upgrade overall. The volume of exports to the EU and Japan in 2012 is higher in absolute figures than in 2002.

Secondly, in the Mutual Expansion and Reverse Competition categories the majority shares of the combined shares for this two categories across different quartiles are found in Quartiles 1 and 2, with 16.4% out of 25.0% of total imports from Malaysia. This pattern of distribution of Mutual Expansion + Reverse Competition category disaggregated by PRODY quartiles reinforces the finding that imports from Malaysia into the US have been upgraded.

Overall, the imports from Malaysia switch from Mutual Expansion to Competitive from 2002 to 2012, the competitive analysis revealing that the competition is mainly for the first and second most sophisticated levels of E&E products. The import structure reveals that Malaysia has upgraded the sophistication of its E&E products.

Next, based on type of goods analysis, the structure of imports from Malaysia in the US market is found to be changing, with the majority comprising Capital Goods, shifting to Parts and Accessories from 2002 to 2012. Only three types of goods are considered in the BEC categorisation in Table 6.6 below, namely Capital Goods, Parts and Accessories and Durables, as the other unlisted categories make up a negligible share of the imports from Malaysia.

Table 6.6 Competitive Analysis by BEC Categorisation: US Market

		2002			2012		
Product Code	Results	No. of Prod.	% of Total Import	% of E&E	No. of Prod.	% of Total Import	% of E&E
41 Capital Goods (except for transport equipment)	Competitive	29	8.5	10.3	44	25.0	39.1
	M. Expansion	65	33.0	39.9	44	2.2	3.4
	R. Competition	1	0.0	0.0	4	0.9	1.4
	M. Withdrawal	2	0.0	0.0	9	0.0	0.0
	N.A.	34	0.0	0.0	30	0.0	0.0
	Total	131	41.5	50.2	131	28.1	44.0
42 Parts & accessories	Competitive	19	1.9	2.2	42	21.7	33.9
	M. Expansion	41	28.9	35.0	24	9.8	15.3
	R. Competition	5	0.0	0.0	1	0.0	0.0
	M. Withdrawal	4	0.0	0.0	4	0.0	0.0
	N.A.	12	0.0	0.0	10	0.0	0.0
	Total	81	30.8	37.2	81	31.5	49.2
61 Durable	Competitive	18	1.8	2.1	21	1.0	1.6
	M. Expansion	19	8.3	10.0	15	2.8	4.4
	R. Competition	0	0.0	0.0	1	0.0	0.0
	M. Withdrawal	3	0.0	0.0	4	0.0	0.0
	N.A.	26	0.0	0.0	25	0.0	0.0
	Total	66	10.0	12.1	66	3.8	6.0
	Grand Total	278	82.2	99.5	278	63.4	99.2

Note: M.=Mutual, R.=Reverse
Source: Own calculations based on UNComtrade

As shown in Table 6.6, under Capital goods the relationship between Malaysian and Chinese E&E imports changes from Mutual Expansion in 2002 to competing for the US market in 2012. In 2002, 39.9% of total Malaysian E&E imports to the US under Capital Goods is in the Mutual Expansion category, but by 2012 the Competitive category overtakes Mutual Expansion with 39.1% of total E&E imports. Comparing the share of each product in Malaysia's total E&E imports into the US between 2002 and 2012, the main item under Capital Goods to decline is *Digital computers with cpu and input-output units* (HS 847120). The item to gain the most in Capital Goods is *telegraphic products and apparatus* (HS 851730 and HS 851782), which include modems and phone and data network switches. This is in line with the analysis of the upgrading of the sophistication of Malaysia's E&E products (see Chapter 8), with Dell Computer shifting its PC manufacturing from Malaysia while companies such as Solectron (later bought and renamed Flextronics) brought the manufacturing of the latest network switches into Malaysia. The shifts 'refocused on server and networking products after 2003, following the almost a complete loss of printed circuit board assembly for PCs and hard disk drives', including bringing the most sophisticated network routers to Penang (Lüthje et al., 2013). Apart from Flextronics, other network switch manufacturers that have plants in Malaysia include Plexus and Jabil Circuits. These manufacturers do not own the brands but manufacture them for famous American network switch and router companies.

In the Parts and Accessories category, Malaysia's key exports items are *Monolithic integrated circuits, digital* (HS 854211), *Monolithic integrated circuits non digital* (HS 854219) and *Parts and accessories of automatic data process* (HS 847330). Comparing 2002 with 2012 in terms of share of imports of Malaysian E&E to the US market, the top growth item is *Photosensitive semiconductor devices, photovoltaic* (HS 854140), which includes solar panel modules and LED lighting devices and rose from 0.7% in 2002 to 10.8% in 2012. Integrated circuits remain the most important item for Malaysia E&E imports into US, and from Mutual Expansion in 2002 they are in competition with imports from China in 2012. The combined share of total US E&E imports from Malaysia of ICs represented by HS 854211 and HS 854219 is 18.7% in 2002 and 22.4% in 2012. Conversely, *computer parts* (HS 847330) exports to the US fell the most in line with Malaysia shifting away from supplying the PC market.[82] The rise of photovoltaic devices can be attributed to the presence of the US MNC First

[82] Computer Parts classified under (HS847330) drop from 11.03% in 2002 to 6.15% in 2012 of total E&E imports from Malaysia into the US.

Solar, which has one of its biggest manufacturing facilities located in Kulim Hi-Tech Park in Kedah, the state next to Penang.

As shown in Table 6.6, the *Durable goods* contribution to total US E&E imports from Malaysia drops from 12.1% to 6.0%, reflecting Malaysia's withdrawal from supplying finished goods to the US, to be increasingly replaced by Chinese imports. Malaysia top loss product is *colour television* (HS 852810), which contracted from 6.6% in 2002 to 0.1% of Malaysia's E&E imports into the US. Conversely, *domestic vacuum cleaners* (HS 850910) increases its contribution to total US E&E imports from Malaysia from 0.03% in 2002 to 1.7% in 2012, becoming an important exports and this is related to the presence of the UK's Dyson in the state of Johor.

Imports from Malaysia were facing intense competitive pressure in the US market from Chinese imports by 2012. The structure of Malaysia's imports into the US market, divided by level of sophistication and the EXPY" index show that it is upgrading its imports. Imports of the more sophisticated E&E products from Malaysia face competition. Finally, Malaysian imports structure disaggregated by type of goods confirms Malaysia's withdrawal from the PC market in the capital goods segment, while increasing focus on high-value network switch and router products. In the Parts and Accessories segment, where the majority of imports from Malaysia are found, US-imported ICs now face competition from China, but photovoltaic and LED products are growing rapidly. Finally in the finished goods segment Malaysia loses in the television market but gains shares in the domestic vacuum cleaner market. The changes in Malaysia's E&E exports to the US from 1992 and 2012 at product level are broadly reflective of FDI presence in Malaysia.

6.3 Competitive Analysis: The European Union Market

The majority of E&E products imported into the EU from Malaysia remain in a relationship of mutual expansion with China's. Malaysia is offering more sophisticated imports to the EU based on the higher EXPY" index score compared to China, and the disaggregated import structure by level of sophistication analysis. A rising share of imports from Malaysia and China in the EU market for capital goods such as network and telegraphic products, and parts and accessories such as computer parts, maintains the overall Mutual Expansion relationship to EU markets over time. Despite this mutual expansion mode, Malaysia's withdrawal from the PC market is still reflected in the type of goods analysis.

Table 6.7 Competitive Analysis of EU markets

	2002			2012			Difference		
Category	No. of Prod.	US$ bn	% of E&E	No. of Prod.	US$ bn	% of E&E	No. of Prod.	US$ bn	% of E&E
Competitive	65	0.6	6.3	122	2.9	20.5	57	2.2	14.2
M. Expansion	234	9.4	92.6	131	11.0	78.3	-103	1.6	-14.4
R. Competition	1	0.0	0.0	7	0.0	0.1	6	0.0	0.1
M. Withdrawal	5	0.1	1.1	51	0.2	1.2	46	0.1	0.1
N.A.	31	0.0	0.0	25	0.0	0.0	-6	0.0	0.0
Total	336	10.1	100.0	336	14.0	100.0	-	3.9	-

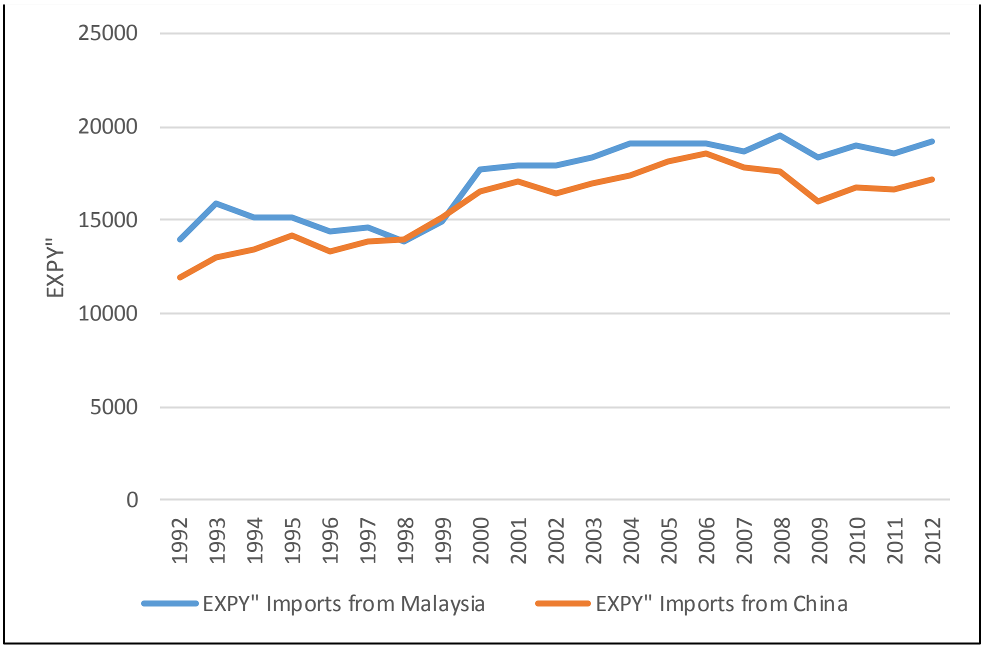
Source: Based on UNComtrade data

The majority of China's imports and Malaysia's imports to the EU market are in the Mutual Expansion category, as shown in Table 6.7, which, despite falling from 92.6% of total E&E imports from Malaysia in 2002 to 78.3% in 2012, remains well above the majority of E&E products. In the Competitive category, shares to total imports from Malaysia in the EU increase from 6.3% to 20.5%, also reflecting China's increasing competition for imports into EU markets. Malaysia lacks clear winning products in the face of China's competition, as represented by the miniscule share of its imports in the EU categorised as Reverse Competition (imports share from Malaysia rising while imports share from China falling).

At the products level, the combined codes *Telegraphic apparatus* (HS 851730 and HS 851782) and *Parts and accessories of automatic data process* (HS 847330) are the two main items contributing to the Mutual Expansion relationship with China's E&E imports to the EU. The value of *Telegraphic apparatus* (HS 851730 and HS 851782) imports from Malaysia rose from US$0.1 billion in 2002 to US$2.3 billion in 2012. Similarly, *Parts and accessories of automatic data process* (HS 847330) rose from US$ 1.0 to 2.3 billion in the same period in strong contrast to the US market, where they fell from US$2.2 to 1.0 billion. A detailed table is available in Appendix 6.2. Tracking the product codes backwards through the 2012 categories, Malaysian' imports remain in mutual expansion with Chinese imports to EU markets. A detailed table is available in Appendix 6.3.

E&E Imports from Malaysia to EU markets shows upgrading of the Malaysian E&E value chain. The EXPY" index was used to compare the sophistication of Malaysia and China's imports at their destination markets. The competitiveness analysis of the E&E imports in the EU market from Malaysia disaggregated by PRODY index quartiles is presented next.

Figure 6.10 EXPY" of E&E Imports from Malaysia and China to EU Markets



Source: Based on UNComtrade data

The EXPY" index of Malaysia is generally above the EXPY" index of imports from China to EU markets except in 1998 and 1999, where China's EXPY" briefly rises above Malaysia's, which is 13918.2 in 1998 compared to China's at 14920.2, and 13972.0 in 1999 with China's at 15108.1. Although Malaysia's EXPY" index is below China's for these two years it should be noted that 1998 is an unusual year for Malaysia with the Asian Financial Crisis in full swing in Southeast Asia.

Next, the competitive analysis disaggregated by sophistication level is presented in Table 6.8 below. By segregating E&E imports from Malaysia to the EU by level of sophistication the changes in import share of each quartile to total imports over time reveal whether Malaysia has upgraded its E&E value chain by offering higher sophistication exports to the EU. The other aim here is to examine whether the relationship between imports from Malaysia and those from China can be discerned by level of sophistication.

Table 6.8 Competitive Analysis of Malaysia and China in EU Imports Based on Sophistication

	2002			2012		
	No. of prod.	% of total imports	% of E&E	No. of prod.	% of total imports	% of E&E export
1st Quartile						
Competitive	14	1.7	2.5	27	4.1	7.7
M. Expansion	61	7.0	10.3	41	12.1	23.0
R. Competition	0	0.0	0.0	1	0.0	0.0
M. Withdrawal	0	0.0	0.0	6	0.0	0.0
N.A.	9	0.0	0.0	9	0.0	0.0
Total	84	8.7	12.9	84	16.2	30.7
2nd Quartile						
Competitive	16	0.1	0.2	32	1.5	2.8
M. Expansion	64	29.9	44.4	37	16.0	30.4
R. Competition	0	0.0	0.0	1	0.0	0.0
M. Withdrawal	0	0.0	0.0	12	0.07	0.1
N.A.	4	0.0	0.0	2	0.0	0.0
Total	84	30.1	44.6	84	17.6	33.4
3rd Quartile						
Competitive	14	0.9	1.4	38	4.1	7.7
M. Expansion	61	22.5	33.4	32	11.5	21.9
M. Withdrawal	1	0.0	0.0	9	0.07	0.1
N.A.	8	0.0	0.0	5	0.0	0.0
Total	84	23.4	34.7	84	15.7	29.7
4th Quartile						
Competitive	21	1.5	2.2	26	1.1	2.1
M. Expansion	48	3.0	4.5	20	1.7	3.1
R. Competition	1	0.0	0.0	5	0.03	0.1
M. Withdrawal	4	0.7	1.1	24	0.5	0.9
N.A.	10	0.0	0.0	9	0.0	0.0
Total	84	5.2	7.8	84	3.3	6.2
Grand Total	336	67.4	100.0	336	52.7	100.0

Note: M. = Mutual, R. = Reverse
Source: Own calculations based on UNComtrade

Consistent with the US market experience, the import structure of Malaysia's EU market is upgrading. Malaysia's most sophisticated imports to the EU rose from 12.9% in 2002 to 30.7% of total E&E goods in 2012, as shown in Table 6.8. Although in the second quartile from 2002 to 2012 Malaysia’s share of total E&E imports to the EU fell from 44.6% to 33.4%, the share in the combined first and second quartile rises to 64.1% in 2012 from 57.5% in 2002. Results in the third quartile see its shares fall from 34.7% in 2002 to 29.7%, while shares in the fourth quartile barely change during the same period.

Overall, the drop in the share of less sophisticated import goods in total E&E imports at destination markets and rise in the share of most sophisticated goods in 2012 compared to 2002 is a sign of Malaysia’s upgrading of its imports to the EU. Finally, majority shares of imports of Malaysia’s E&E into the EU within each PRODY quartile itself fall into the mutual expansion category.

Next, the competitiveness analysis disaggregated by type of goods reveals that Malaysia’s E&E imports to the EU remain mainly in mutual expansion mode across Capital Goods, Parts and Accessories and *Durables*. Parts and Accessories retains its position as the most important type of goods imported from Malaysia to the EU in 2012. This is similar to the US market, where Parts and Accessories become the most important imports from Malaysia and Capital Goods and Durable declined, although the degree of the decline is much lesser. The discussion at product level that follows reveals changes in Malaysia’s exports to the EU, despite Table 6.9 below not showing any notable changes between the shares of the different types of goods.

Table 6.9 Competitive Analysis by BEC Categorisation: EU Market

		2002			2012		
Product Code	Results	No. of Prod.	% of total Import	% of E&E	No. of Prod.	% of total Import	% of E&E
41 Capital goods (except for transport equipment)	Competitive	19	0.8	1.1	48	5.1	9.6
	M. Expansion	96	27.7	41.2	46	15.8	30.0
	R. Competition	1	0.0	0.0	1	0.0	0.0
	M. Withdrawal	1	0.0	0.0	24	0.6	1.1
	N.A.	14	0.0	0.0	12	0.0	0.0
	Total	131	28.5	42.3	131	21.4	40.7
42 Parts & Accessories	Competitive	18	2.4	3.6	33	4.6	8.6
	M. Expansion	56	30.3	45.0	38	22.9	43.5
	R. Competition	0	0.0	0.0	2	0.0	0.0
	M. Withdrawal	2	0.0	0.0	5	0.0	0.0
	N.A.	5	0.0	0.0	3	0.0	0.0
	Total	81	32.7	48.5	81	27.5	52.1
61 Durable	Competitive	19	1.0	1.5	19	0.9	1.6
	M. Expansion	37	3.9	5.7	20	2.0	3.7
	R. Competition	0	0.0	0.0	2	0.0	0.1
	M. Withdrawal	2	0.7	1.1	18	0.1	0.1
	N.A.	8	0.0	0.0	7	0.0	0.0
	Total	66	5.6	8.3	66	2.9	5.5
	Grand Total	278	66.8	99.1	278	51.8	98.3

Note: M.=Mutual, R.= Reverse
Source: Own calculations based on UNComtrade

The top capital goods gaining shares of total Malaysian imports to the EU market in 2002-2012 are similar to those to the US, namely *telegraphic products and apparatus* (HS 851730 and HS 851782); the top decline in terms of share are computers industry related such as *Computer input or output units* (HS 847192) and *Computer data storage units* (HS 847193) (hard disk drives), despite *Computer data storage* remain as the second most important import in the capital goods category in 2012. The change reflects Malaysia’s loss of the PC manufacturing segment, as discussed in Chapter 8.

Parts and accessories remains the major type of products imported from Malaysia to the EU. The top import item is the *IC* (HS854211 and HS854219) at 22.9% of E&E imports in 2002, falling slightly to 19.3% in 2012, but ICs are also the product with the largest loss in terms of share. Conversely, shares of *Parts and accessories of automatic data process* (HS 847330) increase from 10.2% in 2002 to 16.5% in 2012, and this is the fastest growing import category, opposing the declining trend in the US and Japan markets. Computer parts here relate to network adapter cards for PCs, and are mostly manufactured by the Electronic Manufacturing Services (EMS) segment. Second, *Photosensitive semiconductor devices, photovoltaic* (HS 854140) have become important, increasing from 2.4% of Malaysia's E&E exports to the EU in 2002 to 4.8% in 2012. This is reflective of the presence of FDI in Malaysia. Formerly known as Q-Cells, a German based solar module manufacturer has a plant in Selangor, Malaysia, and Osram Opto-semiconductors, which is increasingly shifting to manufacturing LED lighting products, has a long history in Penang. [83]

Malaysia's imports of Durables to the EU fell from 8.3% in 2002 to 5.5% of in 2012 and lost importance as an import category. Consistent with the US market, the highest growth of durable products between 2002 and 2012 is in *Domestic Vacuum Cleaners* (HS 850910), while Malaysia's share of the EU market for audio products such as sound reproduction apparatus and radio receivers goes into further decline. Again, this is due to changing FDI patterns (see Chapter 8).

In conclusion, the majority of Malaysian E&E imports to the EU are largely in mutual expansion with Chinese E&E imports. The competitive analysis disaggregated by sophistication level reveals that Malaysia's imports structure in the EU has upgraded from 2002 to 2012. Finally, the type of

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[83] Q-Cells has been restructured as Hanwha-Q-Cells, with the South Korean company taking over the company in 2012.

goods analysis finds that parts and accessories remain the most important types of goods imported from Malaysia to the EU. Malaysia's imports to the EU are different from those to the US, with computer parts gaining in the EU market. However, Malaysia is withdrawing from exporting PC and audiovisual products such as televisions, similar to the US market. Again, the trade patterns are influenced by the presence of FDI in Malaysia.

6.4 Competitive Analysis: The Japanese Market

In the Japanese market, close to 90.0% of products imported from Malaysia in various categories in 2002 were facing competition from imports from China by 2012. Competitive analysis of E&E Imports from Malaysia into Japan disaggregated by PRODY quartiles again displays upgrading, based on the higher share of products in the first and second levels of sophistication. Secondly, Malaysia and China compete in the imports of sophisticated E&E goods, including ICs, to the Japanese market. The type of goods analysis shows that Japan is structurally different in that about a fifth of its imports from Malaysia are durable goods, in contrast to the US and EU markets, where durables are no longer a significant part of Malaysia's imports by 2012.

Table 6.10 Competitive Analysis: Japan

	2002			2012			Difference		
Category	No. of Prod.	US$ bn	% of E&E	No. of Prod.	US$ bn	% of E&E	No. of Prod.	US$ bn	% of E&E
Competitive	79	0.7	14.3	127	3.3	60.8	48	2.6	46.5
M. Expansion	136	3.9	83.3	70	1.7	31.0	-66	-2.2	-52.4
R. Competition	11	0.1	2.3	14	0.4	8.2	3	0.3	5.9
M. Withdrawal	3	0.0	0.1	32	0.0	0.0	29	0.0	-0.1
N.A.	107	0.0	0.0	93	0.0	0.0	-14	0.0	0.0
Total	336	4.7	100.0	336	5.4	100.0	-	0.8	-

Note: M.=Mutual, R.=Reverse Competition
Source: Own calculations based on UNComtrade

China competes with Malaysia for Japan's E&E, as shown in Table 6.10 above. More Malaysian E&E products face competition with imports from China in 2012 than in 2002, as the Competitive category share of Malaysia's total E&E imports rises by 46.5%, and the Mutual Expansion category falls by 52.2%. Interestingly, in 2012 in the Reverse Competition category the Japanese market's share of E&E total imports rose from 2.3% in 2002 to 8.2%. This is discussed further under competitiveness analysis based on type of goods.

Table 6.11 Distribution of Competitive Analysis Outcomes in 2012 to 2002 According to E&E Product codes (Japan Market)

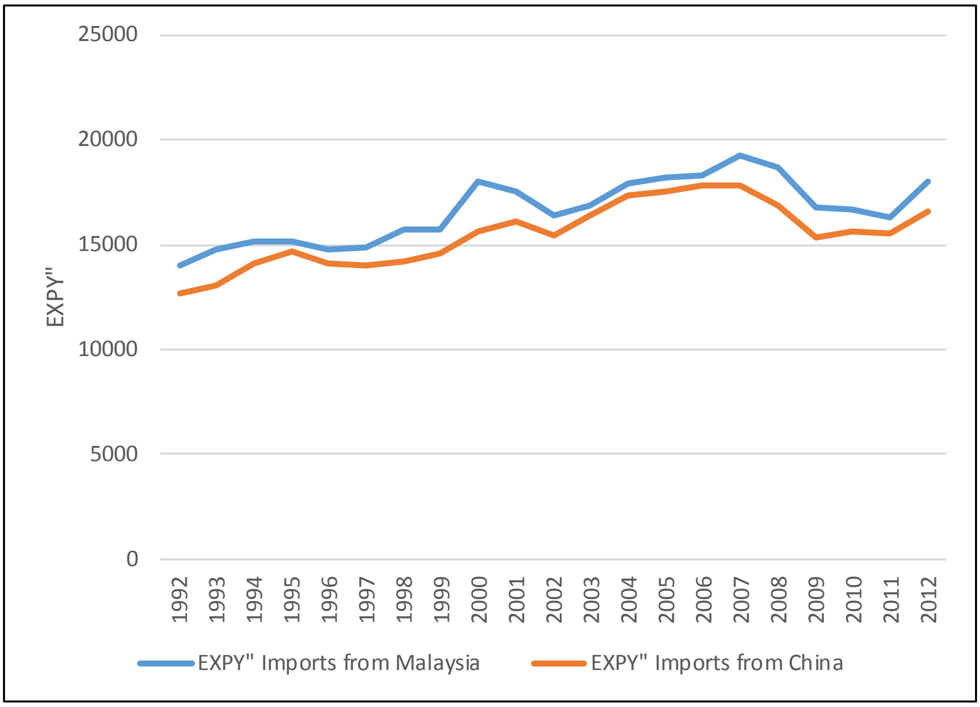
Category	No. Prod	US$ bn	% of E&E	Category	No. Prod	US$ bn	% of E&E
Competitive	33	0.4	9.5	Competitive	127	3.3	60.8
M. Expansion	85	3.6	77.0				
R. Competition	5	0.1	2.1				
M. Withdrawal	1	0.0	0.1				
N.A.	3	0.0	0.0				
Total	127	4.2	88.7				
Competitive	24	0.2	4.1	M. Expansion	71	1.7	31.0
M. Expansion	30	0.2	3.2				
R. Competition	4	0.0	0.0				
N.A.	13	0.0	0.0				
Total	71	0.3	7.4				
Competitive	5	0.0	0.1	R. Competition	14	0.4	8.2
M. Expansion	3	0.1	1.5				
N.A.	6	0.0	0.0				
Total	14	0.1	1.6				
Competitive	12	0.0	0.6	M. Withdrawal	31	0.0	0.0
Mutual Expansion	17	0.0	0.8				
R. Competition	2	0.0	0.2				
Total	31	0.1	1.6				
Competitive	5	0.0	0.0	N.A.	93	0.0	0.0
M. Expansion	1	0.0	0.8				
M. Withdrawal	2	0.0	0.0				
N.A.	85	0.0	0.0				
Total	93	0.0	0.8				
Total	336	4.7	100.0	Total	336	5.4	100.0

Note: M. = Mutual, R. = Reverse
Source: Own calculations based on UNComtrade

Malaysia competes with China for E&E imports to Japan; 88.7% of all of Malaysia's E&E imports to Japan in 2002 faced a competitive relationship with Chinese E&E imports in 2012, as shown in Table 6.11 above. Malaysia's greatest competition with China in the Japanese market is for *Monolithic integrated circuits, digital & Non-Digital* (HS854211 and HS854219): the former's export value of which falls from US$1.0 billion in 2002 to US$ 0.7 billion in 2012. The top gain product in terms of share to the total Malaysia E&E imports into the EU that falls into the Complementary category is *Telegraphic apparatus* (HS 851730 and 851782), which rises from US$50.1 million in 2002 to US$672.9 million in 2012. Malaysia competes with China to export E&E products to Japan. A detailed table of the top items in Competitive, Mutual Expansion and Reverse Competition is available in Appendix 6.4.

Next I examine whether imports from Malaysia to Japan display upgrading based on the "EXPY" index of Malaysian and Chinese imports at their destination markets, followed by a detailed analysis of competitive analysis based on PRODY index quartiles. The "EXPY" index of Japan's E&E imports from Malaysia are consistently above those from China. Imports from Malaysia have a higher level of sophistication than Imports from China at the destination markets, as shown in Figure 6.11 below.

Figure 6.11 Malaysia and China EXPY" for E&E Imports into Japan



Source: Own calculations based on UNComtrade

The competitive analysis disaggregated by sophistication level reveals that Japan's E&E imports from Malaysia reflect the upgrading of the latter's E&E value chain from 2002 to 2012, as shown in Table 6.12 below. This is based on the share of the second quartile to the Malaysia's total E&E imports into Japan declining from 43.9% in 2002 to 29.4% in 2012 and those of the first quartile correspondingly increasing from 9.3% to 29.6% of total E&E imports. The share of the third quartile also declines to a lesser degree from 2002 to 2012, while the fourth quartile remains the same. Overall, the level of sophistication of Malaysian imports to the Japanese market is growing.

Table 6.12 Competitive Analysis of Malaysia and China's Imports to Japan based on Level of Sophistication

	2002			2012		
	No. of products	% of total imports	% of E&E	No. of products	% of total imports	% of E&E export
1st Quartile						
Competitive	12	0.6	1.5	25	2.3	13.2
M. Expansion	32	3.3	7.8	25	2.8	16.3
R. Competition	5	0.01	0.01	5	0.0	0.0
M. Withdrawal	1	0.0	0.0	3	0.0	0.0
N.A.	34	0.0	0.0	26	0.0	0.0
Total	84	3.9	9.3	84	5.1	29.6
2nd Quartile						
Competitive	19	1.3	3.2	40	3.6	20.8
M. Expansion	47	17.0	40.6	18	1.2	7.2
R. Competition	1	0.0	0.1	3	0.2	1.4
M. Withdrawal	0	0.0	0.0	6	0.0	0.0
N.A.	17	0.0	0.0	17	0.0	0.0
Total	84	18.4	43.9	84	5.1	29.4
3rd Quartile						
Competitive	21	2.9	6.8	34	2.5	14.7
M. Expansion	36	8.5	20.3	16	0.8	4.4
R. Competition	1	0.5	1.2	4	0.7	3.9
M. Withdrawal	1	0.0	0.1	9	0.0	0.0
N.A.	25	0.0	0.0	21	0.0	0.0
Total	84	11.9	28.5	84	4.0	22.9
4th Quartile						
Competitive	27	1.1	2.7	29	2.1	12.1
M. Expansion	21	6.1	14.7	11	0.5	3.1
R. Competition	4	0.4	1.0	2	0.5	2.9
M. Withdrawal	1	0.0	0.0	13	0.0	0.0
N.A.	31	0.0	0.0	29	0.0	0.0
Total	84	7.7	18.3	84	3.1	18.1
Grand Total	336	41.8	100.0	336	17.3	100.0

Note: M.=Mutual, R.=Reverse

Source: Own calculations based on UNComtrade

The majority of Malaysian imports face competition from Chinese imports across all levels of sophistication except for Quartile 1. The top item in the Mutual Expansion category in Quartile 1 is *telegraphic apparatus* (HS 851730 and HS 851782). However, within Quartile 1 in 2012, the share of products categorised as Competitive stood at 13.2% of total E&E imports, not far behind the 16.3% share categorised as Mutual Expansion. Conversely, competition in the Japanese market for the second quartile is mainly due to competition from China for *Monolithic Digital and Non-digital ICs* (HS 854211 and HS 854219).

Based on the competitive analysis disaggregated by level of sophistication for the Japanese market, E&E imports from Malaysia upgrade from 2002 to 2012. The majority of Malaysian' imports compete with Chinese exports at all levels of sophistication except the most sophisticated segment. It is also notable that in the Mutual Expansion category the majority shares at all levels of sophistication are in Quartile 1, at 16.3% out of the 31.0% of total imports from Malaysia categorised as Mutual Expansion. This reinforces the finding that imports from Malaysia to Japan are being upgraded.

Next I present findings of the competitiveness analysis disaggregated by type of goods in the Japan market. The analysis found that unlike the US and EU market trends the Japanese structure is unique: first, Malaysian imports of Parts and Accessories to Japan decline as a share of the total, and secondly, Malaysia retains a sizeable share of Japan's durable imports, which contains household electrical goods from 2002 to 2012. As shown in Table 6.13 below, shares of total E&E imports of Parts and Accessories declined from 41.3% in 2002 to 35.8% in 2012 and the share of durables remains sizeable and largely unchanged at around 22.0%.

Table 6.13 Competitive Analysis by BEC Categorisation: Japanese Market

		2002			2012		
Product Code	Results	No. of Prod.	% of total Import	% of E&E	No. of Prod.	% of total Import	% of E&E
41 Capital goods (except for transport equipment)	Competitive	26	3.6	8.5	44	3.4	19.5
	M. Expansion	47	9.8	23.5	27	3.3	19.0
	R. Competition	6	0.5	1.2	8	0.3	1.6
	M. Withdrawal	2	0.1	0.1	9	0.0	0.0
	N.A.	50	0.0	0.0	43	0.0	0.0
	Total	131	14.0	33.4	131	6.9	40.0
42 Parts & accessories	Competitive	24	1.9	4.5	38	4.8	27.8
	M. Expansion	41	15.1	36.1	17	1.4	8.0
	R. Competition	1	0.3	0.8	3	0.0	0.0
	M. Withdrawal	1	0.0	0.0	9	0.0	0.0
	N.A.	14	0.0	0.0	14	0.0	0.0
	Total	81	17.3	41.3	81	6.2	35.8
61 Durable	Competitive	13	0.4	0.9	20	2.1	12.2
	M. Expansion	21	8.9	21.3	10	0.6	3.4
	R. Competition	4	0.1	0.3	2	1.1	6.6
	M. Withd	0	0.0	0.0	8	0.0	0.0
	N.A.	28	0.0	0.0	26	0.0	0.0
	Total	66	9.4	22.4	66	3.8	22.2
	Grand Total	278	40.6	97.1	278	16.9	98.1

Note: M.=Mutual, R.=Reverse
Source: Own calculations based on UNComtrade

The relationship between Japan's Malaysian and Chinese E&E imports of capital goods is almost equally split between Competitive (19.5% of total imports) and Mutual Expansion (19.0% of total imports) in 2012. However, the degree of competition has increased in the capital goods category, with only 8.5% of total imports in 2002 facing competition from China, rising to 19.5% by 2012. At the product level, Malaysia loses in the computer industry with four out of ten items in the Competitive category with the largest decline in share of Malaysian imports related to the computer industry (HS 8471). The top category is again *telegraphic products and apparatus* (HS 851730 and HS 851782), rising from 1.1% to 12.4% of Malaysia's total E&E imports in Japan.

Looking at parts and accessories, the top import is again computer industry-related. The combined share of Malaysian E&E imports to Japan of HS 854211 and HS 854219, *Integrated Circuits*, notably drops from 22.0% in 2002 to 12.6% in 2012, with the highest loss of share in Parts and Accessories. *Parts and accessories of automatic data process* (HS 847330) also declined from 5.5% in 2002 to 2.1% of E&E imports in 2012. Conversely, as in the US and EU markets, *Photosensitive semiconductor devices, photovoltaic* (HS 854140) rise from 1.8% in 2002 to 5.3% in 2012 as product gaining the biggest share of total E&E imports. Interestingly, Malaysia's imports of *Parts for radio/tv transmit/receive equipment, nes* (HS 852990) in the Japanese import market also grow from 2.5% to 4.1%, reflecting the presence of Japanese FDI in Malaysia in the form of Sharp and Panasonic's television manufacturing facilities and Panasonic's has a solar module manufacturing facility in Kulim Hi-Tech Park in Kedah.

The fall from 41.3% in 2002 to 35.8% of Malaysia's E&E imports of Parts and Accessories in 2012, diverges from the common understanding within the regional production network literature, where Malaysia increasingly specialises more in parts and components exports while relinquishing more of its final goods trade. The decline in Japan's demand for Parts and Accessories can be explained by the shift of its manufacturing base to China. The fall in *Monolithic Digital ICs* imports to Japan are counteracted by increasing digital IC exports from Malaysia to China, driven by user industries such as mobile phones, tablets, and household electrical production capacity, which are increasingly moving to China from around the world. For example, Malaysian exports to China of HS *Monolithic Integrated Circuits, Digital* (HS 854211) in 2002 had a value of only US$0.6 billion compared to US$5.5 billion in 2012. According to field interviews, Japanese E&E firm are going factory-light, no longer manufacturing but sourcing products from China. Secondly, Japanese E&E firms lost their market leader status to Korean giants such as Samsung and LG in the area of consumer electronics in the late 1990s and therefore required fewer parts and components as they produce and sell less in the global market.

Finally, as shown in Table 6.13, Malaysia's share of the Japanese market for Durable Goods, remains at 22.2% in 2012 compared to 22.4% of total E&E imports to Japan in 2002. However, the relationship between Malaysian and Chinese durable goods imports into Japan switches from Mutual Expansion to Competitive from 2002 to 2012. Interestingly, the top products here are in the Reverse Competition category. Durables remain an important import to Japan for Malaysian companies. The product that increases its quantum of share to the total E&E imports in durable import is the same as in the US and EU markets, namely *domestic vacuum cleaners* (HS 850910). The domestic vacuum cleaner and audio products such as *Radio receivers, portable, with sound recording or reproducing apparatus* – commonly known as MP3 players (HS 852711) –gaining a share of Malaysia's E&E imports to Japan from 2002 to 2012 and account for the bulk of the 6.6% of imports to Japan under Reverse Competition in the Durable category. This import from Malaysia is strong in the face of competition from China.

Durable products' resilience in the Japanese market is partly explained by FDI presence in Malaysia. Imports from Malaysia *of domestic vacuum cleaners* (HS 850910), are improved by the presence of the UK's Dyson, which has a plant in Senai, Johor, and Panasonic also has a vacuum cleaner plant in Shah Alam, Selangor.

Malaysia's E&E imports to Japan face competition from China. Based on competitive analysis disaggregated by sophistication, Malaysia has upgraded its imports structure over time. The Japanese market is unique among the three destination markets in that about a fifth of its imports from Malaysia are durable goods (finished goods). This again reflects Japanese FDI in Malaysia.

6.5 Malaysia's response to the loss of its durables market in the US and EU

Apart from upgrading, taking the example of *d*urable imports to the US such as colour televisions, Malaysia is diverting its exports to Middle East markets as a response to China's rise. The top import item that saw its share to Malaysian E&E imports decline in the US is *Colour television receivers/monitors/ projectors* (HS 852810), which fell from US$1.3 billion or 6.6% of total E&E imports to US$ 18.4 million or 0.1% by 2012.

In the EU, Malaysia's imports of audio-visual equipment went into further decline. Products such as *Radio-telephony receiver, with sound reproduce/record* (HS 852731) fell from 2.9% of E&E imports to the EU in 2002 to 1.1% in 2012; *Colour television receivers/monitors/ projectors* (HS 852810) declined from 1.1% to 0.6%, and *Other sound reproducing apparatus* (such as transcribing machines) (HS 851999) also declined from 1.0% in 2002 to 0.4% in 2012.

On the other hand, China has 28.1% of the US import market for *Colour television receivers/monitors/projectors* (HS 852810) by 2012, as shown in Table 6.14 below. In contrast to the decline in the US and EU market for durables, *Colour television receivers/monitors/projectors* (HS 852810) remain an important for Malaysian exports to Japan, maintaining at US$0.5 billion (31.8%) in 2002 to US$0.5 billion (18.5% of total Japanese imports of colour television imports) in 2012. Despite this, colour television switches from Mutual Expansion in 2002 to a Competitive relationship with Chinese imports by 2012 based on competitiveness analysis in the previous section.

Table 6.14 Colour Television (HS 852810) Imports at Destination Markets: Comparison of China and Malaysia's market shares

Destination	China: share of total imports			Malaysia: share of total imports		
	1992	2002	2012	1992	2002	2012
US	4.6%	7.8%	28.1%	7.7%	13.0%	0.1%
EU	3.7%	1.7%	12.3%	3.2%	0.9%	0.3%
Japan	4.7%	42.0%	62.5%	18.0%	31.8%	18.5%

Source: Based on UNComtrade data

Malaysia's resilience in the Japanese television market is supported by Japanese FDI in Malaysia, notably Sharp and Panasonic televisions, which are produced in Malaysia. Sharp has moved much of its manufacturing facility from Japan to Batu Pahat, Johor (interviewee 4). Another possible explanation could be geographical distance, as Malaysia is closer to Japan than to the US and EU, and with televisions bulky items, the cost of transportation could also play a role in Japan's continuing imports of colour televisions from Malaysia.

This rest of this section discusses Malaysia's withdrawal from importing *Colour television receivers/monitors/projectors* (HS 852810) to the US and EU, with reference to the household electrical sector in general. It discusses Malaysia's firm-level response to China's rise in E&E and answers the research question: How are Malaysia's firms responding to the rise in China's E&E trade and investment?[84]

In this discussion of Malaysia's withdrawal from the television industry at the destination markets, some export data is discussed in conjunction with the equivalent import data to give a fuller picture of the television industry. China is the world biggest exporter of colour televisions in 2012, as shown in Table 6.15 below. The high growth of China's television exports data

[84] Malaysian respond in investment aspects is in Chapter 8.

coincide with the rise of China's electrical goods MNCs such as ChangHong, Haier and Skyworth.

Table 6.15 World Exports of Colour Television (HS 852820) by country

Country	1992 US$ bn	WMS %	Country	2002 US$ bn	WMS %	Country	2012 US$ bn	WMS %
Japan	2.4	20.5	Mexico	6.7	20.5	China	21.8	25.0
S.Korea	1.4	12.7	Japan	3.7	11.3	Mexico	17.5	20.1
Mexico	1.3	11.7	Malaysia	2.2	6.9	Slovak Republic	6.4	7.4
Singapore	1.3	11.4	China	2.2	6.8	Poland	4.9	5.6
Germany	1.0	8.7	Korea, Rep.	2.1	6.3	Hungary	3.8	4.4
Malaysia	0.8	7.2	Turkey	1.5	5.1	Malaysia	3.7	4.3
Thailand	0.7	5.8	France	1.4	4.5	Czech Republic	2.4	2.7
US	0.6	5.0	Spain	1.2	4.2	Germany	2.3	2.6
China	0.5	4.6	Thailand	1.1	3.8	Turkey	2.2	2.5
Spain	0.4	3.8	Poland	1.1	3.3	Korea	1.8	2.1
Others	1.0	8.5	Others	9.5	27.4	Others	20.4	23.4
Total	11.4	100.0	Total	32.6	100.0	Total	87.2	100.0

Source: Based on UNComtrade data

Although Malaysia competes with China to export *Colour television receivers/monitors /projectors* (HS 852810) to destination markets especially in the US, Malaysia adapted to China's rise by diverting its exports to Middle East markets. The importance of the Middle East for Malaysia's electrical products was affirmed in field interviews. As shown by the export data in Table 6.16, Malaysia has switched its main exports of colour television from its traditional markets such as Singapore and the US to the United Arab Emirates (UAE) by 2012. UAE is host to the Jebel Ali Free Trade Zone, where major Middle East distributors are located. Moreover, by 2012 Malaysia sources at least half of the parts for its colour television production from China (see Table 6.17). Overall, Malaysia still manages to increase its exports of colour televisions from US$2.2 billion in 2002 to US$3.7 billion in 2012 in absolute terms.

Table 6.16 Exports of Malaysian Colour Televisions (HS 852810) by Destination, Malaysia as Reporter

Destination	1992 US$ bn	Share of total (%)	Destination	2002 US$ bn	Share of total (%)	Destination	2012 US$ bn	Share of total (%)
Singapore	0.2	24.5	US	1.1	47.5	UAE	0.8	20.3
US	0.1	15.2	Japan	0.5	22.1	Japan	0.5	13.4
UAE	0.1	8.1	Singapore	0.2	8.6	Australia	0.5	13.0
UK	0.1	7.4	UAE	0.1	6.2	India	0.3	8.3
Germany	0.1	7.3	Australia	0.1	2.6	Saudi Arabia	0.3	7.7
Japan	0.05	5.8	Belgium	0.04	1.6	Singapore	0.2	6.3
HK	0.04	4.3	Finland	0.03	1.5	Vietnam	0.2	5.2
Saudi Arabia	0.03	3.3	Saudi Arabia	0.03	1.4	Indonesia	0.2	4.8
The Netherlands	0.03	3.2	Hong Kong	0.02	1.0	Thailand	0.2	4.6
Chile	0.02	2.9	Canada	0.02	0.8	New Zealand	0.1	2.6
Others	0.1	17.9	Others	0.1	6.6	Others	0.5	13.8
Total	0.8	100.0	Total	2.2	100.0	Total	3.7	100.0

Source: Based on UNComtrade data

Table 6.17 Imports of *Parts for radio/tv transmit/receive equipment, nes* (HS 852990) from Trade Partners into Malaysia, Malaysia as Reporter

Destination	1992 US$ bn	Share to Total (%)	Destination	2002 US$ bn	Share to Total (%)	Destination	2012 US$ bn	Share to Total (%)
Japan	0.3	47.9	China	0.2	17.3	China	1.0	50.1
Singapore	0.2	30.5	Japan	0.2	16.9	South Korea	0.3	13.5
Other Asia	0.03	4.9	Sweden	0.1	9.7	Japan	0.2	10.4
US	0.03	3.9	South Korea	0.1	9.5	Hong Kong	0.2	8.9
Germany	0.03	3.8	US	0.1	8.4	Thailand	0.1	3.6
South Korea	0.02	2.6	Singapore	0.1	7.1	Other Asia	0.1	3.5
Hong Kong	0.01	1.9	Hong Kong	0.1	6.3	Singapore	0.1	2.6
China	0.01	1.0	Thailand	0.1	5.1	US	0.04	2.0
UK	0.01	0.8	Other Asia	0.1	4.6	Sweden	0.02	1.1
Sweden	0.01	0.7	Indonesia	0.04	3.8	Philippines	0.01	0.7
Others	0.01	2.0	Others	0.1	11.4	Others	0.1	3.5
Total	0.7	100.0	Total	1.1	100.0	Total	2.1	100.0

Source: Based on UNComtrade data

Field interviews captured issues in the electrical sector not identified by quantitative analysis. For example for some local Malaysian companies in the electrical sector that do not manufacture all the things they sell, China's impact is positive. A Penang-based electrical company, Pen1, out-sources much of its manufacturing to China, but keeps the market information, trading, brand name and technology in Malaysian hands. The strategy is to take advantage of the competitive price of Chinese' manufacturing while increasingly selling products under Malaysian brand names in ASEAN, with and forays into Middle East markets. In this sense, the rise of China is positive for this company in Malaysia. Interestingly, while Chinese products can compete with Pen1 in destination markets, but Pen1 works together with Chinese manufacturers for sourcing of supplies of its products. Therefore competition and complementary forces co-exist on the ground for industrialists. In a sectoral basis at the national level, some firms are negatively affected by competition from China, while others firms that benefit from its rise.[85] Field interviews reveal it is not possible to decide whether China is purely a competitive or a complementary force; Pen1 finds it predominantly complementary to this Penang-based company. In game theory language, cooperative and compete strategies for the players are the solution to this game.

When companies such as Pen1 source products from China the UNComtrade database records more exports from China, which tilts the bilateral trade balance towards deficit, but in reality Pen1 mentioned that at the company's strategic level China helps medium-sized companies to manage risk. This is because in the E&E industry the fast rate of change in design and types of goods demanded involves investing in new

[85] Smaller size Malaysian electrical firm such as Milux, which manufacture small electrical items such as fans, are reported to be negatively affected by Chinese competition (Euromonitor International, April 2013).

manufacturing lines, which cannot physically be changed fast and can be a risky investment.

Apart from upgrading, Malaysian firms divert their exports to destinations other than their traditional markets such as the US, EU and Japan, such as the Middle East such as the colour TV exports. Finally, qualitative interviews in a Malaysian-owned company in the electrical sector revealed a complementary factor, namely managing investment risks.

6.6 Conclusion

Malaysian E&E products face competition from China for imports to the US and Japan, while their relationship regarding EU markets is broadly one of mutual expansion. The structure of imports from Malaysia to these three markets shows consistency, with Malaysia upgrading its E&E exports. Malaysia changed from supplying finished goods to supplying more parts and accessories, except in Japan, showing its shifting role in the regional production network to be broadly consistent with the regional production network literature (Athukorala, 2009). In the Japanese market a sizeable proportion of imports from Malaysia remain durables, such as finished household electrical goods while the share of parts and accessories declines. In addition, Malaysia increasingly faces competition from China for IC chip imports to both the US and Japan. Consistent with the evolution of China's E&E industry (see Chapter 4), this marks a change in Chinese exports from finished goods to more sophisticated parts and accessories such as IC chips. The change may erode the complementary trade identified by scholars such as Athukorala and Kophaiboon (2014). However, the case of China eroding the complementary trade simply by increasing its share of exports is not that straightforward, as discussed in Chapter 8 (section 8.3).

This chapter has also found that while China competes for E&E imports, especially to the US and Japan, Malaysia has upgraded the sophistication of its imports to the three destination markets. Indeed the competition from Chinese for E&E imports is 'a blessing in disguise, […] catalysing serious upgrading efforts' Ernst (2004, pp. 113.) Competitiveness analysis disaggregated by sophistication also informs the debate between Shafaeddin (2004) and Lall and Albaladejo (2004) about whether China competes with its neighbours, since the level of the sophistication of their exports are different. This chapter has shown that China is competing in the most sophisticated parts and components. In the US and Japanese markets China's ICs compete with those of Malaysia. Despite Malaysia upgrading its exports, it lacks clear winning products in the face of China's competition.[86]

A third major finding is that trade patterns are broadly in line with the FDI pattern that originates from the trade partner. This is more pronounced in the Japanese market than in any other. Malaysia's Imports of durables to Japan are resilient, despite the competitive pressure from Chinese imports in 1992-2012. This could be partly explained by the heavy Japanese MNC presence in Malaysia's E&E sector (Edgington and Hayter, 2013). Another example of trade patterns being reflective of FDI presence is the loss of PC manufacturing, which is further elaborated in Chapter 8 when the Dell Computers case is discussed.

Apart from upgrading, Malaysia's loss of its durable goods market share at destination markets, as demonstrated in the case of colour televisions, Malaysia has responded by diverting its exports to the Middle East,

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[86] Although in Japanese market, domestic vacuum cleaners are gaining shares and falls into Reverse Category (Malaysia imports share rising, China's imports share declining) under Competitive Analysis but it is again FDI related.

importing parts and components from China. The sourcing of parts from China is inconsistent with (Athukorala and Kophaiboon, 2014), who stress that China is at the receiving end of the parts and components trade. Field interviews with a Malaysian firm added the perspective that China is complementary to this Malaysian-owned medium-sized electrical company as it helps it to manage its investment risks.

Although the findings in Chapter 6 show that China competes with Malaysia for E&E exports, based on competitiveness analysis at the destination markets such as the US and Japan, Malaysia's total world exports of E&E actually increased from US$54.3 billion in 2002 to US$ 77.0 billion in 2012. This increase was achieved despite falling exports to US markets and slow growth in the EU and Japan. Therefore it is important not to lose sight of the fact that this slower growth and decline in export volume in the case of the US were supported by demand from China, and that China is Malaysia's number-one trade partner with a major role in the production network.

7.0 Product Upgrading by Semiconductor Equipment Manufacturers in Malaysia

This chapter analyses China's effect on backward linkages in Malaysia's E&E industry. Backward linkages refer to supporting industries, and in this chapter the focus is on semiconductor backward linkages, in particular those in the semiconductor equipment machinery (SEM) industry that are directly involved in manufacturing IC chips, such as processors, memories, and amplifiers, under HS code 8542. Malaysia's SEM exports grew on average by 15.5% per annum from US$0.6 billion in 2002, representing 0.6% of Malaysia's total exports, to US$2.8 billion, or 1.2% of total exports, in 2013. Although the contribution to total exports remains small, SEM is growing rapidly and has the potential capitalise on the semiconductor industry presence in Malaysia. Detail export value is in Table 7.1 below.

Table 7.1 Export Value of the SEM industry in Malaysia

	Total in US$ bn	Share of Total Exports (%)	Share of Total Manufactured Exports (%)
2002	0.6	0.6%	0.8%
2003	0.7	0.7%	0.8%
2004	1.0	0.8%	1.0%
2005	1.3	0.9%	1.2%
2006	1.4	0.9%	1.2%
2007	1.5	0.8%	1.2%
2008	1.3	0.7%	1.2%
2009	1.3	0.8%	1.2%
2010	2.4	1.2%	1.8%
2011	2.6	1.1%	1.8%
2012	3.7	1.6%	2.6%
2013	2.8	1.2%	2.0%

Note: For share of total manufactured exports the denominator is obtained using summation of trade value of Chapter 5-8 of SITC Rev.3 nomenclature.
Source: Own calculations based on UNComtrade

This chapter discusses the upgrading of Malaysia's semiconductor value chain through the backward linkages. As discussed in Chapter 6, semiconductors are a major industry in the E&E sector, and here I provide a granular analysis of whether Malaysia has upgraded the backward linkages in its SEM segment, and whether China plays a role in in this upgrading. [87]

The upgrading of Malaysia's SEM industry is related to the question of whether China's rise has a competitive or a complementary effect on Malaysia's semiconductor industry. This chapter finds that SEM has grown with China's complementary effect, defined here as China creating new demand for Malaysian exports. This is significant, as Ernst (2004) has argued that China can still have a positive effect provided challenges caused by its rise spur Malaysia towards upgrading.

This chapter also focuses on SEM because of the high technology and specialised skills used in its production. Sykes and Yinug (2006, p.3) describe how SEM 'is used in perhaps the most complex and advanced manufacturing process in the world, the production of semiconductor devices'. Although much has been written about semiconductor industry in Malaysia, at present to the researcher's best knowledge, scholars have yet to discuss Malaysia's SEM industry in relation to the China's rise in the region.

Finally, it is important to establish whether China's rise spurred Malaysia to upgrade. This question is answered by analysing trade data and a case study of Penang Vision Corporation (name changed) in Penang, a company that designs optical semiconductor inspection equipment.

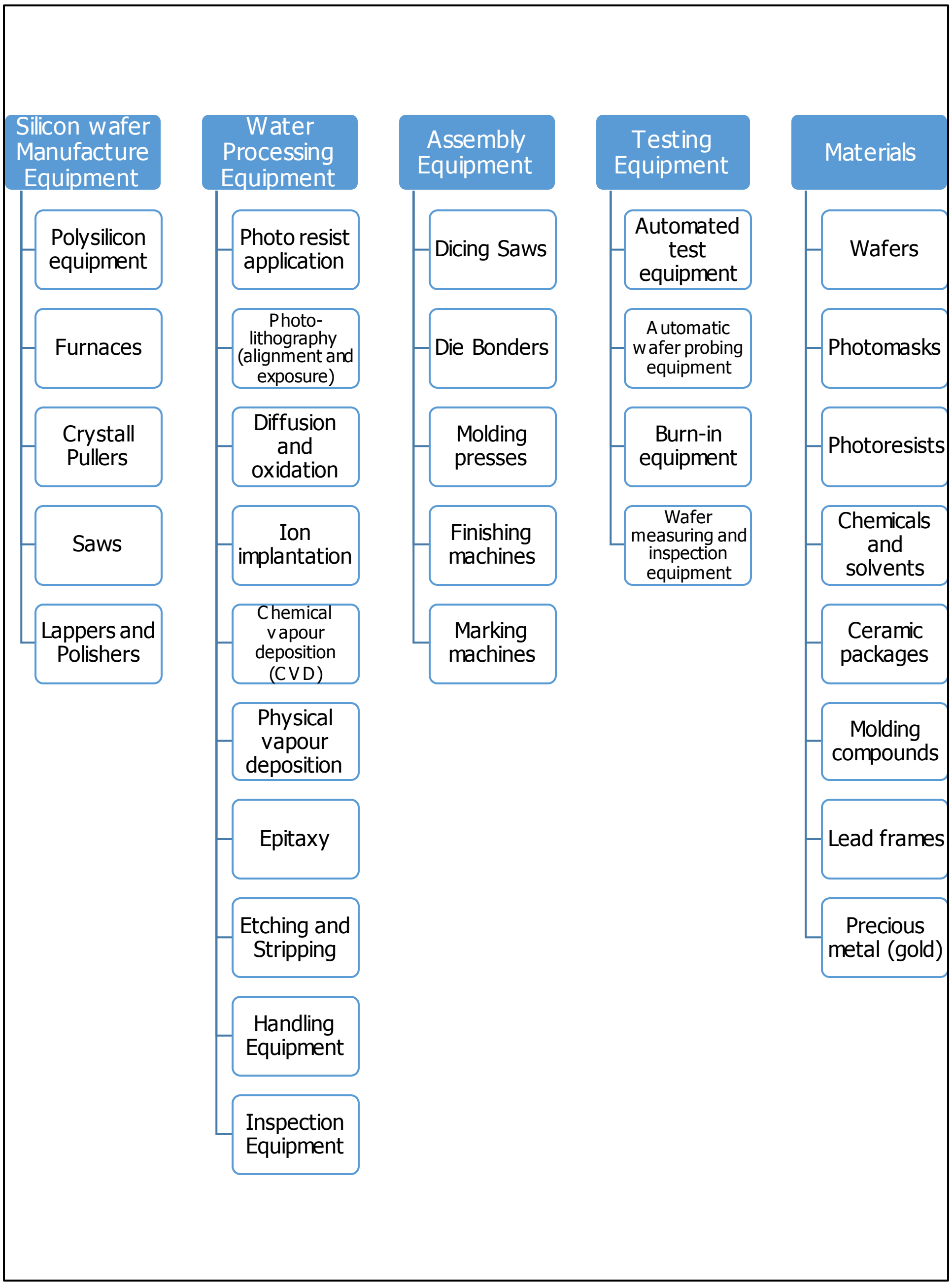
[87] Granular here simply means at a product level, in detail, as opposed to highly aggregated data such as in macro-economic level.

The rest of the chapter is structured as follows: the background to SEM in Malaysia is presented first, followed by the methodology, the data sources, and the findings. Towards the end of the chapter, various theoretical frameworks explaining the SEM industry in Malaysia are compared such as spin-off theory (Klepper, 2002) and spatial embeddedness. Finally the chapter concludes that China is complementary to the SEM segment, with special reference to semiconductor wafer test machines.

7.1 Backward linkages of the semiconductor industry in Malaysia

To provide a background, SEM can be divided according to the five major stages of semiconductor production as shown in Figure 7.1 below. Malaysia's role in the semiconductor GVC, which specialises in assembly and testing, influences the country's strength at producing machinery for this stage of processing in the semiconductor industry. The operations of semiconductor companies in Penang started with assembly and testing in the 1970s. As the semiconductor industry grew, the local supporting industry began to evolve from initially dominated by Japanese SMEs (Rietema and Velden, 2013). By the 1980s and 1990s a group of Malaysian-owned companies, which began as SMEs, emerged from initially providing jigs and fixtures for semiconductor companies to building the machines themselves and become public-listed companies.

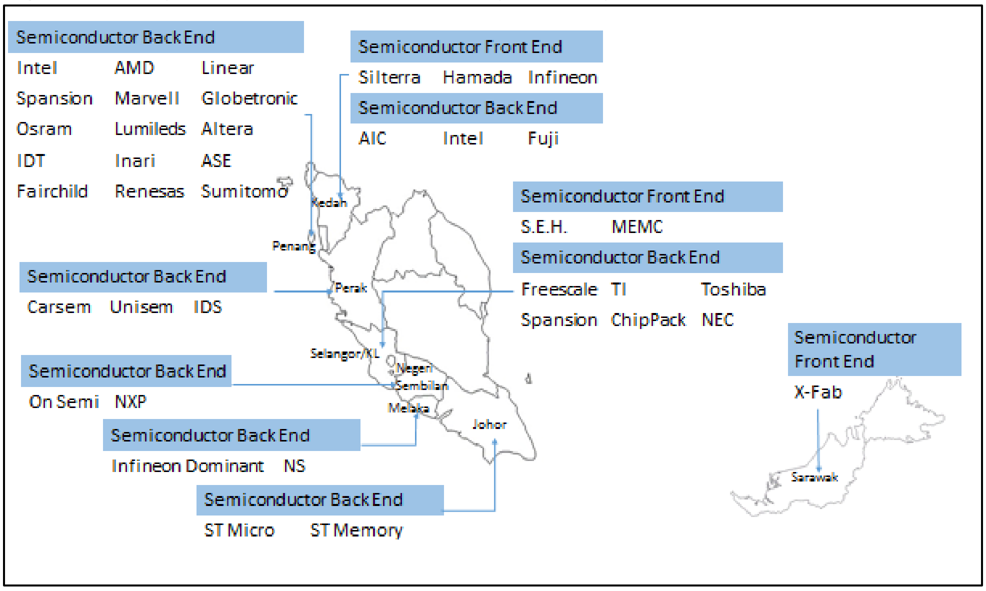
Figure 7.1 Semiconductor Equipment Manufacturing Industry Structure



Source: US International Trade Commission (1991)

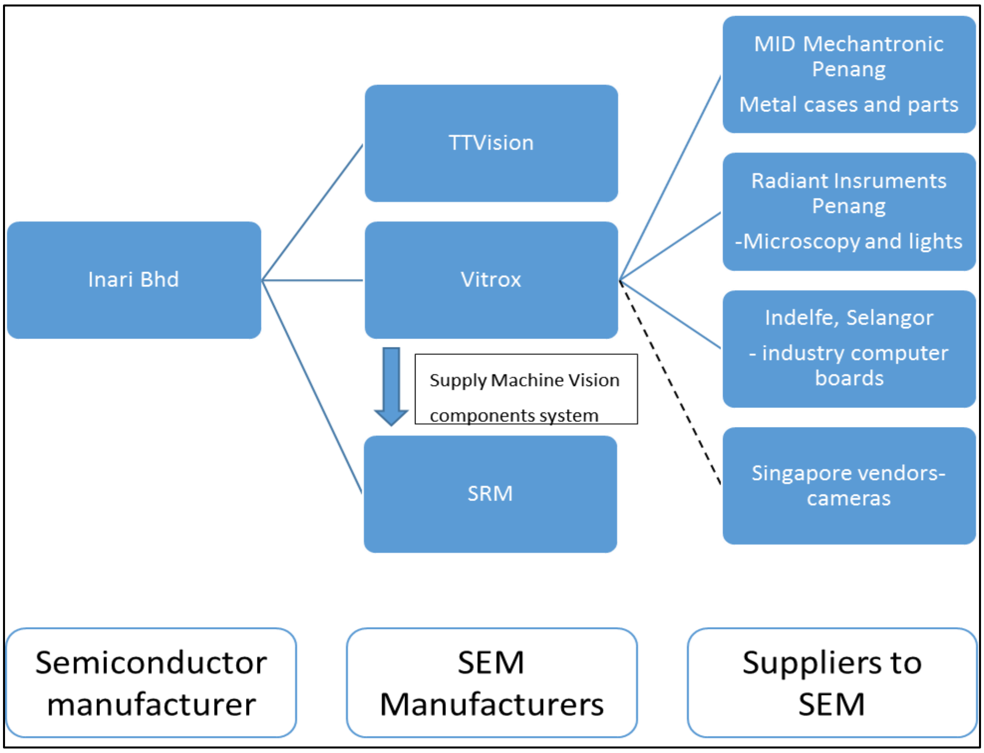
Figure 7.2 maps the semiconductor industry in Malaysia. SEM is linked to the semiconductor industry especially in Penang State.

Figure 7.2 Map of Semiconductor Industry in Malaysia



Source: MIDA

Figure 7.3 Example of the Backward Linkage of Penang SEM to a Semiconductor Manufacturer (Inari Bhd)



Source: Own elaboration based on interview data and Corporation B (2008)

Ernst's GPN framework (Chapter 2) encompasses the backward linkages of the semiconductor industry (Ernst, 2004). Thoburn (1973) defined a linkage as ‘an investment opportunity offered by one industry to another’ and according to Hirschman (1958, in Thoburn 1973, pp. 91-92) ‘backward linkages’ is defined as ‘investment in industries the production of inputs for the industry in question’. For backward linkages definition, the input here specifically refers to the production machinery for the industry in question, namely the semiconductor industry.[88] Figure 7.3 above illustrates an example of the link between semiconductor companies and Malaysian SEM players in Penang. SRM, Vitrox, and TT Vision supply test handler machines used to automate inspection of ICs packaged by Inari-Amertron Bhd in Penang. For simplicity, Inari-Amertron is referred as Inari Bhd in this chapter.

Recall that Alavi (2002) argues that Malaysia’s export-oriented industries such as electronics and its import substitution industries such as steel and automobiles are not linked, creating dualism in its industrial structure. Alavi describes Malaysia’s E&E industry as ‘basically an assembling activity and therefore the imported input contents are very high, 98 per cent of total outputs’ (Alavi, 2002, pp. 55).[89] This high imported content continues to feature, as found in field interviews about the present semiconductor industry in Penang. However, as this chapter unfolds, and once the backward linkages are considered, a picture emerges that is different from Alavi’s description of Malaysia’s E&E industry.

Secondly, while Taiwan and South Korea quickly adapted to the manufacturing process and upgraded to advanced manufacturing techniques in the IC industry, Malaysia is still dependent on foreign MNCs in the IC chip value chain. There is limited upgrading activity in the

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[88] As a further illustration of backward linkages, Thoburn shows that the primary commodities boom in Malaysia created demand for indigenous light engineering for mining machinery, especially in the tin mining industry. Details in Thoburn (1973).
[89] A Central Bank of Malaysia Report quoted in Alavi (2002, p.55), puts imported inputs around 80-85%, which is considered high import content for the electronics industry.

semiconductor industry but the Malaysian workforce has manufactured more complex products since 2000, and R&D activities for MNCs based in Malaysia. Manufacturing higher specification products than previously is regarded as product upgrading, and R&D is regarded as functional upgrading in the GVC literature. Malaysia's case is different, with its major upgrading found in the backward linkages instead, and specifically in the SEM segment for the testing and assembly of IC chips.

This SEM value chain is important. Field interviews found it to be one of the most dynamic areas for Malaysian-owned firms, the success of which was linked (without claiming causality) to China. Therefore the SEM segment merits a closer look in the form of a case study at firm level.

7.2 Methodology and data sources

The methodology used in this chapter is both quantitative and qualitative. There are some similarities in the quantitative methods to those used in Chapter 6 but the data coverage is different, hence the discussion of the methodology is located in this chapter instead.

The quantitative methods include balance of trade and revealed comparative advantage (RCA). Briefly, the balance of trade at the product level reveals which Malaysian products are likely to be competitive if they are in surplus. These surplus products are further examined for evidence of upgrading to see whether Malaysia is riding on China's rise in the semiconductor industry. Next, the RCA is used to identify in which out of 36 SEM products Malaysia has a comparative advantage. Detailed RCA formulae are provided in Chapter 3 and a full list of the 36 products is available in Appendix 7.1.

The trade codes for this chapter is based on HS 2002 nomenclature for data period of 2002-2013 for 36 product codes and this differs from the HS1988/92 nomenclature that was used in Chapter 5 and Chapter 6. This is because the HS 2002 nomenclature is better suited to reflect the IC production process, which is explained in section 7.2.1. SEM products contain only 3 of the 338 E&E products discussed in Chapter 6.[90] A full list of SEM products by stage of production is available in Appendix 7.2. The switch to the use of HS2002 rather than the HS1988/92 nomenclature is because the earlier nomenclature HS1988/92 does not disaggregate the use of machinery into semi-conductor and non-semiconductor use.

As a result of this switch to HS 2002 nomenclature the data period for this chapter is 2002-2013. While the disadvantage that some product items are not disaggregated into semiconductor use and non-semiconductor use remains even when HS2002 nomenclature is adopted, this problem is now minimised and most importantly, the main subject of discussion in this chapter, namely optical machines for wafer inspection, is not affected.

Result findings based on balance of trade and RCA are compared with data gathered from field interviews with Penang-based semiconductor players, SEM players and Malaysian government officials. The SEM companies selected for study are mostly public listed companies. Non-public listed companies are included in the chapter if they are linked to the local production network traced backwards from Inari Bhd, a back-end semiconductor player. Due to access issues I used purposive sampling for interviews and relied on secondary sources such annual corporate reports to verify the findings. The list is checked against InvestPenang's list of

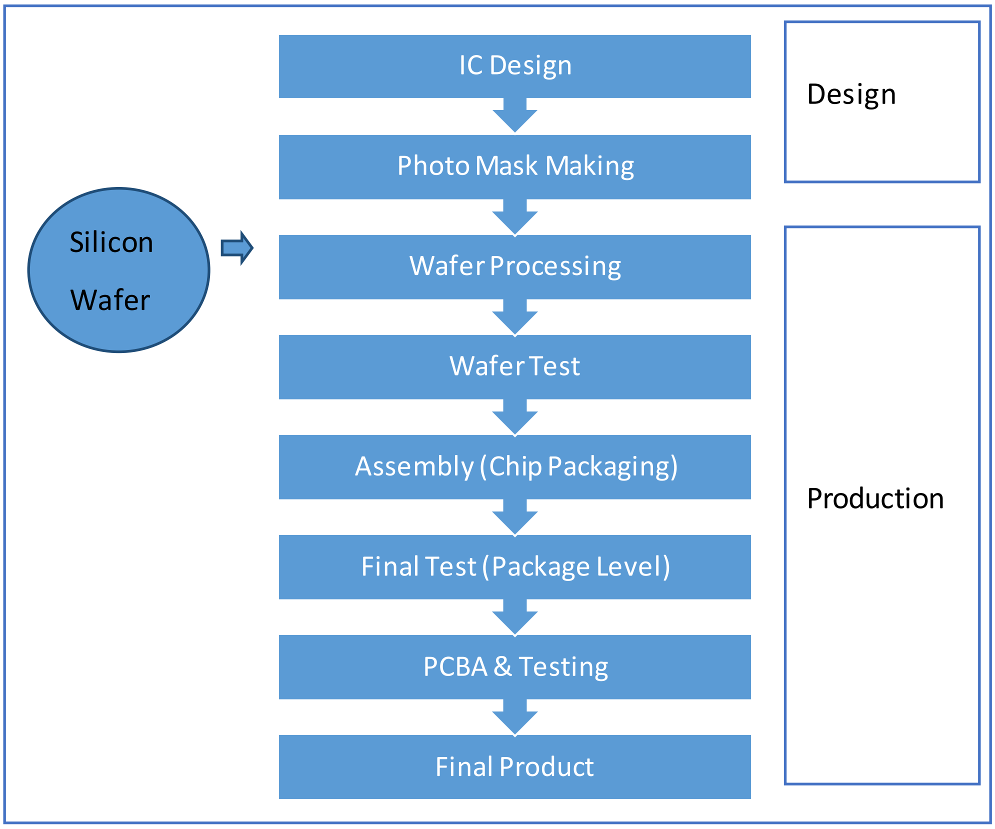
[90] With the exception of HS codes 854311, 854389, 854390, all other product codes covered in this chapter are not covered in the previous trade chapter with its 338 product codes.

companies and Grunsven (2006) list of automation companies (which includes jigs and fixture or machining companies) in Penang.

7.2.1 The IC production process

Next, the semiconductor value chain is based on the IC production process, is shown in Figure 7.4 below. An understanding of the IC production process is essential to explaining the coverage of the SEM products in this chapter.

Figure 7.4 Semiconductor Machines by Stages of Productions in IC Industry



Source: Adapted from Silterra Corporation Malaysia

Available at: http://www.silterra.com/supply_chain.html

Figure 7.4 shows an overview of the production of semiconductors.[91] The IC value chain begins with the design of the IC and photo-mask making. At the end of the IC design phase the IC is sent for a process called 'taping out' (part of the photo-masking stage) or prototyping, where its design is adjusted before it moves into the mass production process.

The semiconductor production process can be generally divided into front-end and back-end activity. The front-end process refers to the fabrication of silicon wafers, while the back-end process involves the packaging of the IC, which completes the IC production process. The front end of the semiconductor industry is higher value than back end because of the complexity of its production process. The machines used to fabricate the silicon wafer have higher-technology specifications than those at the back end. A full explanation of each step in the IC production process is available in Appendix 7.3.

The fabrication of semiconductors is referred as the front-end of the industry and includes processing and testing the wafer. Once the wafer is fabricated it is tested using of customised probing machines to weed out defective wafers.

After this the fabricated wafers are shipped to another location and assembly and packaging process called the back-end process. The fabricated wafers are sawed into individual units (referred to as die from this point forward), packaged and connected to a gold wire with a lead frame. The encapsulated ICs are then trademarked using lasers. In the final stage of production the IC chips are visually checked and tested to see that they function as intended. The chips that pass the tests are now ready for

[91] The semiconductor is an umbrella term that covers IC, memory and amplifiers chips. In this section the words IC and semiconductors are used interchangeably.

shipment in the form of either tape or a tray. A graphic representation of the back-end process is available in the findings section (Figure 7.5).

Finally, a qualitative case study is informative and can provide much needed detail on how China's rise affects a particular industry. Although arguably not every industry would be affected by China in the same way, the SEM industry, and especially the testing segment, is at the core of Malaysian-owned companies' specialisation and as such merit a closer look. This is a young industry in Malaysia – Penang Vision started in 2000 and Aemulus in 2004 – and it is unclear at this point in time whether the success of semiconductor test machines will spread to other segments of Malaysia's E&E industry.

7.3 Findings

Malaysia's strength in the semiconductor industry is in the back-end or 'test and assembly' segment of the industry. This segment is central to the discussion in this section. At times it is called automation, referring to the automation of the IC test and assembly operation that was previously carried out manually on an assembly line following initial inward FDI into Malaysia by MNCs in the IC packaging activity taking advantage of the country's low labour costs in the 1970s.

By the late 1990s this Malaysian low cost model became untenable after countries such as China, Vietnam and Cambodia offered themselves as low-cost manufacturing bases for MNCs. However, as an early starter Malaysia has developed capability in the automation of assembly and test operations Malaysia is no longer engages in low-technology manufactures such as manual IC testing and assembly in the semiconductor value chain. As this chapter will reveal, there is more to Malaysia's semiconductor achievements than the generalisation that it performs low-technology test and assembly activities.

7.3.1 Upgrading of the Semiconductor Equipment Manufacture Value Chain in Malaysia

This section discusses the upgrading of the SEM value chain. Field interviews in Penang revealed that local chip-making companies used locally built and supplied SEM machines together with imported ones on their production lines. Malaysian firms and the machinery used at the back-end of the semiconductor process are as follows: SRM specialises in manufacturing semiconductor test handlers; Pentamaster builds its own test handler machines and offers an automation service bundle; Vitrox specialises in optical inspection machines; TTVision provides solutions for optical inspection machines in semiconductors and has branched out into solar photovoltaic module machine inspection, Aemulus specialises in designing semiconductor tester machines; and Exis designs and builds 'pick and place' semiconductor machines.[92] All the companies mentioned here are based in Penang except Exis, which is based in Seremban, Malaysia.

A graphical representation of the participation of Malaysian' SEM players' participation in the back-end stage of production is shown in Figure 7.5 below:

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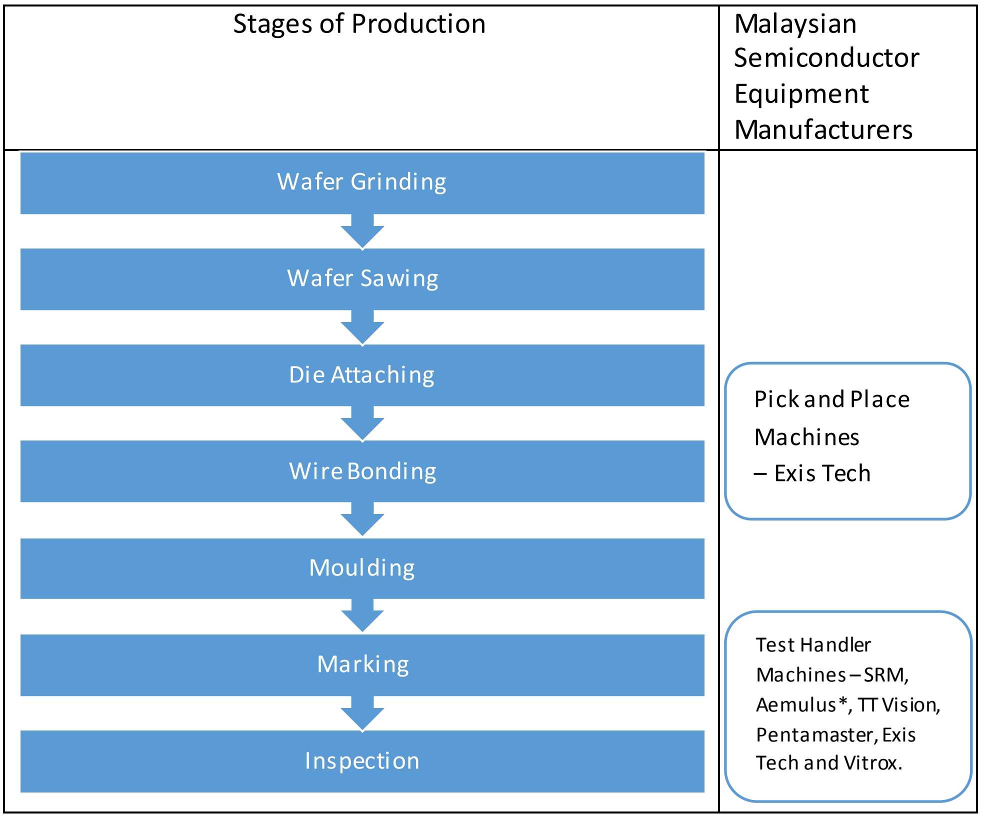
[92] Automation service bundle includes consultation services of how to automate the production line and this goes beyond semiconductor industry, Pentamaster has automation solutions for rubber glove (for medical use) industry.

Figure 7.5 Stages of Production in the Back-end Stage of Semiconductor



Note: Depending on the layout of factory shop floor, the figure above shows where SEM is likely to be located. Variations on factory shop floors are expected, but most have a final inspection and testing of the packaged IC.
* Aemulus has recently built Radio-Frequency (RF) probe testing machines for the front-end of semiconductors, which require higher technology than back-end machines.
Source: Adapted from Chen et al. (2010), field interviews and secondary sources

As shown in Figure 7.5 above, Malaysia's firms concentrated on machinery for testing at the back end of the semiconductor industry. At firm level, this strategy is good as firms should concentrate on what they do best, but at the national industry level it is better to diversify into other back-end activities in the industry. Nevertheless, this represents a good start (for inspection machines) for Malaysian firms. Malaysian policymakers should encourage SEM firms to make more complex machines for semiconductor manufacturing at other stages of production as well.

Next, Table 7.2 tabulates the characteristics of major SEM players in Malaysia.

Table 7.2 SEM players with selected characteristics

Companies	Year Founded	Revenue (RM m) – Reporting Year	Revenue (US$ m)	No. of Employees	Front-End/Back-End Inspection
Pentamaster Corporation Bhd.	1991	81.0 -2014	24.75	226	Back-end automation solutions for other industries
SRM	1996	Private information	N.A.	N.A.	Back end
TT Vision	2001	12.0 -2007	3.49	N.A.	Back end and solar wafer inspection
Aemulus	2004	23.0 -2014	7.03	50	Front end and back end
EXIS Tech	2002	54.0 -2011	17.65	70	Back end and dental imaging equipment
Penang Vision	2000	169.9-2014	51.91	270	Back-end and PCB boards
MMS Ventures Bhd	1997	36.7-2014	11.21	80	Back end and LED inspection machines
Inari Bhd *	2005	793,655 - 2014	242,496	1,320	N.A.

N.A.=not available from private companies such as Aemulus and EXIS Tech. Employment and revenue data obtained from various media sources.
*Revenue figures and no. of employees based on Inari-Amertron, a merger of Inari and Amertron.
Source: Various

The main market for SEM products is mainly for exports to the US and China. Aemulus's the main markets are China and the US (TV3 Channel Malaysia, 2014). MMSV's main market is in the US and US MNCs based in Asia (Tan, 2014c). SEM players in Penang are competing internationally and this necessitates their constant innovation in the competitive environment.

Most SEM equipment makers in Malaysia perform their own R&D. However, SEM's R&D efforts would be classified as achieving level 5 of Rasiah's taxonomy of different levels of R&D, a level short of the frontier R&D, meaning it can create new nodes or branches of products (Rasiah, 2010). This finding is consistent with interviews with Inari Bhd that advanced inspection machines for high tech RF chips requires higher specification machines are still being imported from Europe because local companies has yet to produce them. However, when Malaysia's firm do make the back end inspection machines; SRM test-handler machines are said to be on par with a well-known Swiss-made test handler machines called ISMECA.

Going forward, there are potential spinoffs from Malaysia's testing equipment in the SEM cluster, since some firms are diversifying into other sectors with their knowledge of SEM machinery (see Table 7.2).[93] For example, Pentamaster is providing automation machines for rubber glove manufacturers while Exis Tech has branched out into building dental imaging machines.

Despite the downside of being concentrated on the testing segment of SEM, these are high-technology machines.[94] Penang Vision Corporation Berhad (see Table 7.2), which designs high-technology optical inspection machines, has been selected as a case study as it has the highest revenue among Malaysian-owned SEM players in Malaysia. Penang Vision also designs Advanced Optical Inspection (AOI) machines for PCB inspection in the assembly process. An AOI machine carries an indicative price of about US$123,000.[95] They are highly specialised and requires a skilled workforce to produce and maintain them. They have to be reliable, given that the tested IC chips or boards will be embedded in the latest smartphones and

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[93] Clusters are defined 'as sectoral and spatial concentrations of firms' (Schmitz and Nadvi, 1999).

[94] On average 6 products (HS code 903082, 903090, 903141, 903149, 903180, 903190) that test equipment comprised 57.95% of total SEM from Malaysia to China and 51.65% of Malaysia's total SEM exports in 2002-2013 (see Appendix 7.4).

[95] US$ conversion based on £80,000, price of AOI machines obtained at a trade show in Farnborough England, therefore the indicative price is not specifically priced for Penang Vision-made machines.

tablets. This is a high-growth sector, outpacing industrial average growth from 2002-2013.[96]

As a corporate strategy, Penang Vision differs from typical Malaysian mid-size firms found in Penang. Penang Vision is a R&D driven company, with 15% of its revenue reinvested into R&D every year, and two-thirds of its employees in R&D. Penang Vision does not manufacture its own products and subcontracts the building of its machines. More details are provided in the later part of this section where I discuss the company's production network.

As an example of its upgrading of its products, Penang Vision has won multiple awards for its machine vision products (for advance x-ray inspection of PCBs) including international awards such as the EDN award for Best in Test in 2014 and the NPI[97] award in the test inspection category for its V810 model which has a throughput of 50,000 boards per hour.[98] These international awards prove that Malaysia's firms are producing world-class SEM products. In the 2014 EDN test machines category Penang Vision joined other winners such as Opticon, based in the Netherlands, and Mirtec, which is headquartered in Seoul (Rowe, 2013). Penang Vision exemplifies the upgrading of the E&E value chain's backward linkages.

Notwithstanding the above achievements, field interviews revealed that Malaysian-made semiconductor machines are still a step below European-made semiconductor machines which are used to inspect radio-frequency (RF) chip in the back-end segment. RF chips require higher-technology

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[96] See Figure 7.7, item under HS code 903082.
[97] NPI awards stands for Circuits Assembly New Product Introduction Awards. Circuits Assembly is a US-based magazine that specialises in circuit boards.
[98] EDN's original name is Electrical Design News. EDN is part of the UBM Tech Network online community for the electronics industry. UBM Tech is a global media tech company that specialises in providing events at which important industrial players can discuss and display latest machines.

machines, and these are still supplied by European makers. However Aemulus in Penang recently made its maiden forage into a RF-front end tester segment with the Amoeba 7600 machine.[99] The company was founded in 2004 and has experienced 60% growth on average per year. A news report states that there are only two companies capable of building RF probe testers, both in China, that compete with Aemulus in the Asian region' (Karamjit Singh, 2013). Aemulus's success in producing RF probe testers for the front-end segment again shows that Malaysia is upgrading its SEM products.

Given the ultra-competitive environment in the semiconductor industry proper, producing capital goods for the semiconductor industry is a wise strategy for Malaysia's future industrial policy. According to Moore's Law, the speed of the microprocessor will double every six months, which also means that the price of microprocessors will halve every six months. This strategy also avoids competing head-on with China's ambitious assault on the semiconductor market.

Finally, referring to the chip making industry, Ernst (2004) points out that the high imported content of Malaysian E&E exports, due to its dependence on North American MNCs located in Malaysia, means minimal benefits for Malaysian firms. This is not the case with semiconductor inspection machines. A Malaysian SEM player revealed that 30-40% of the value of the final product is provided by local inputs in contrast to the much lower local content in the semiconductor industry (interviewee 5).

The case study of Penang Vision is presented to show its more extensive local linkages with SEM compared to the semiconductor industry to infer about higher local content within SEM products. As the discussion of

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[99] RF is Radio Frequency Wafer. These will end up as RF-Chips that are used in smartphones or mobile tablets, for telecommunication purpose.

vendors and suppliers is sensitive due to the non-disclosure agreements amongst industry players in the E&E value chain, one way to track the suppliers is to trawl through the annual reports of a public listed company. Based on this method, three of the five vendors that list themselves as a vendor of Penang Vision are Malaysian companies, two of which are based in Penang. (Corporation B, 2008, pp.18-22.) The vendors in Penang supply opto-engineering and microscopy devices and the mechanical frame, including the laser-marking component, of the machine. The third known Malaysian company is based in Selangor and is a system integrator for production needs and a supplier of industrial computers. Although it cannot be generalised to the whole E&E industry in Penang, based on its annual reports Penang Vision displays a greater use of local vendors and content compare to the semiconductor industry. Triangulating this data with evidence from the qualitative interviews, it is likely that 30-40% local content in optical semiconductor testing devices is a reasonable estimate. This is higher than the semiconductor (chip-making) industry national average, based on low value-adding figures. In the chip-making industry, the majority of inputs consist of wafers that are fabricated overseas and imported for further processing.

Another important criterion for an industry that displays upgrading, as Ernst (2004) points out is the network of producers. Penang Vision supplies SRM, a major test handler manufacturer based in Penang and a major customer for Vitrox's machine vision systems.[100] A newspaper reports that SRM orders provide up to 65% of Vitrox's revenue (Loong, 2007). To fulfil its orders Penang Vision outsources its manufacturing to its subcontractors. This allows it to focus on the design and development of new machines. Some of its suppliers include Penang-based MID mechatronics, which

[100] Test handler machines lift individual IC chips/die from a specially built tray and scan them using a machine vision for quality control. Then the machine arranges the chips on a tape or discards them.

supplies mechanical parts, metal machine frames and laser markers for IC production machines. Radiant Instruments, also based in Penang, supplies Penang Vision with vision light and optical and microscopy instruments, and Indelfe, a Selangor-based embedded systems manufacturer and industrial computers supplier that integrates systems and creates production-line solutions.

Apart from this formal production network, field interviews revealed that informal networking is also crucial to the success of some successful companies in Penang. The Chairman of Penang Vision Corporation, Kiew Kwong Sen is also the CEO of Mini Circuits Technology Malaysia that is also based in Penang, is mentoring a group of Penang E&E entrepreneurs. There are also non-electronics industry mentors who play a part in SEM entrepreneurs' success. Ng Sang Beng, the founder of Aemulus benefits from the advice and early-stage funding from Kwok Chok Bee, a venture capitalist based in Malaysia (Karamjit Singh, 2014). Finally, Penang Vision was founded by the a ex-Hewlett Packard (HP) employee, and when Agilent (an HP spin-off) wanted to sell off two business divisions, Advanced Optical Inspection (AOI) and Advanced X-Ray Division (AXI) in 2008, Penang Vision bought them both and re-hired the engineers from Agilent. The networking among E&E players in Penang beyond the firms that they worked in and of entrepreneurs networking with financiers shows the informal side of networking in Penang's E&E industry.

In conclusion, the case study of Penang Vision shows that SEM players are upgrading the value chain in Malaysia, although this has not been discussed in the literature. This upgrading conforms to Ernst (2004) criteria, which include higher use of local content and establishing a network in production.

7.3.2 Links to China?

Having established SEM upgrading in Malaysia, the next question is whether Penang Vision's upgrading is linked to China. To investigate this I use both primary data – interviews – and secondary data including trade statistics, press reports and annual corporate reports.

In Penang Vision's 2008 Annual Report the managing director's message specifically mentioned China: 'Our improved AOI flagship products, Challenger HS1802 & VF-10 have been successfully accepted by our customers in China' (Corporation B, 2008, pp.11.). Newspaper reports also present China as the main destination for Penang Vision's exports products:'[Penang Vision is] looking to appoint one agent in Taiwan, three in China and "one or two" in Malaysia' (Loong, 2007). Logically, the number of agents in a geographical region can be indicative of the source and volume of business. In addition, field interviews with Penang Vision's co-founder affirmed that demand from China aided the company's expansion during the crucial years 2007-2008. 2007 is a high growth phase of Penang Vision, and 2008 saw Penang Vision acquires two divisions from HP to expand its product offering. China aided the rise of Penang Vision as a company through additional demand, as discussed later in this section.

Although a bit of extension, TT Vision, based in Penang, which started with the manufacture of semiconductor test machines, branched out into designing tester machines for solar photovoltaic modules which it sells to Chinese solar module manufacturers.[101] Although the photovoltaic module is not part of the IC industry it is relevant as it is within the E&E sector.

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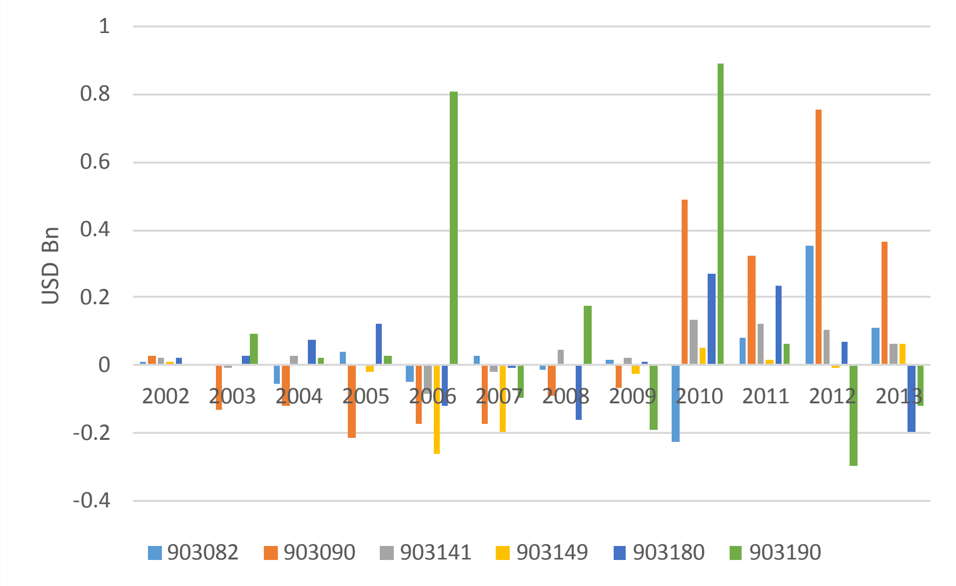
[101] Based on interviews with policymakers in a government planning agency.

Quantitative analysis of the trade balance with China and the RCA index discussed in the next section finds that the trade data is consistent with the findings from the qualitative interviews as it reveals that semiconductor inspection machines are indeed Malaysian local firms' strength. This section now looks at the foreign exchange rate and detailed trade data by destination to investigate China's link to SEM demand at a case study level. I start with the trade balance.

a) Trade Balance

As shown in Figure 7.6 below, while the overall trade balance for SEM (based on 36 products) is negative (see Appendix 7.5), the SEM testing segment does not follow the overall trend. Testing machines reverted to trade surplus from 2010, and *Optical instrument & appliances. for inspecting semiconductor wafers/devices/ for inspecting photomasks/reticles used in manufacturing semiconductor devices* (HS903141) have been in trade surplus since 2008. These semiconductor testing machines are the bright side for Malaysia's E&E impacted by the rise of China with rising Malaysia in destination markets like the US and Japan.

Figure 7.6 Malaysia's Trade Balance with China for Selected Semiconductor Manufacturing Machines with Trade Surplus



Source: Own calculations based on UNComtrade

Table 7.3 HS Codes Description for Selected SEM Products

HS codes	Description
903082	Instruments & apparatus for measuring or checking semiconductor wafers or devices
903090	Parts & accessories of the instruments & apparatus of 90.30
903141	Optical instr. & appliances. for inspecting semiconductor wafers/devices/for inspecting photomasks/reticles used in manufacturing semiconductor devices
903149	Optical meas./checking instruments & appliances, n.e.s. in Ch.90
903180	Measuring/checking instruments, apparatus. & machines, n.e.s. in Ch. 90
903190	Parts & accessories of the instruments, apparatus. & machines of 90.31

Source: Based on UNComtrade

b) Revealed Comparative Advantage (RCA)

The RCA calculates which of Malaysia's 36 SEM products have a comparative advantage and finds seven products that are the most important for Malaysia (with RCA>1 score), six of which are used in wafer inspection/testing machines, as shown in Table 7.4 below. This includes optical instruments for semiconductor inspection as discussed in the case study later in the chapter. Full RCA calculations are available in Appendix 7.6.

Table 7.4 Selected RCA Index (Products with most RCA>1) for Malaysia's Semiconductor Manufacturing Equipment

	HS Product Code						
Year	**901090**	**903082**	**903090**	**903141**	**903149**	**903180**	**903190**
2002	0.12	0.59	1.92	0.24	0.25	0.49	2.56
2003	0.13	1.19	2.81	0.45	0.35	0.46	2.18
2004	1.02	0.48	3.35	0.20	0.19	0.67	1.70
2005	0.76	0.46	4.11	0.11	0.38	0.30	3.81
2006	0.14	0.86	4.53	0.25	0.35	0.33	4.07
2007	1.76	0.64	5.23	0.20	0.58	0.31	2.69
2008	1.71	2.79	6.11	1.26	0.56	0.48	2.20
2009	0.86	3.04	6.06	0.99	0.60	0.62	1.49
2010	1.81	4.27	9.91	1.03	0.39	0.88	3.54
2011	2.21	6.23	9.64	1.70	0.16	0.80	2.25
2012	2.30	16.99	17.44	0.96	0.11	0.55	4.08

Source: Own calculations based on UNComtrade

Table 7.5 HS Codes Description of Selected Malaysia's SEM products

HS codes	**Description**
901090	Parts & accessories for apparatus of 90.10 (Direct Write on Wafers Machine)
903082	Instruments & apparatus for measuring/checking semiconductor wafers/devices
903090	Parts & accessories of the instruments & apparatus of 90.30 (Oscilloscopes, spectrum analysers)
903141	Optical instr. & appliances for inspecting semiconductor wafers/devices/for inspecting photomasks/reticles used in manufacturing semiconductor devices
903149	Optical meas./checking instruments and appliances, n.e.s. in Ch.90
903180	Measuring/checking instruments, apparatus & machines, n.e.s. in Ch. 90
903190	Parts & accessories of the instruments, apparatus & machines of 90.31 (Measuring or checking instruments, appliances and machines)

Source: UNComtrade

Although Table 7.4 shows that *Parts & accessories of the instr. & app. of 90.30 (Oscilloscopes, spectrum analysers)* (HS code 903090) has a consistent revealed comparative advantage (RCA>1) from 2002-2013, this is not the focus here, due to the presence of Agilent Technologies in Penang, a US-based MNC that designs and produces test and measurement machines. Instead, the items of interest are *Instruments & app. for measuring/checking semiconductor wafers/devices* (HS 903082) and *Optical instruments. & appliances for inspecting semiconductor wafers/devices/for inspecting photomasks/reticles used in manufacturing semiconductor devices* (HS903141), where most of the Malaysian-owned players are situated.

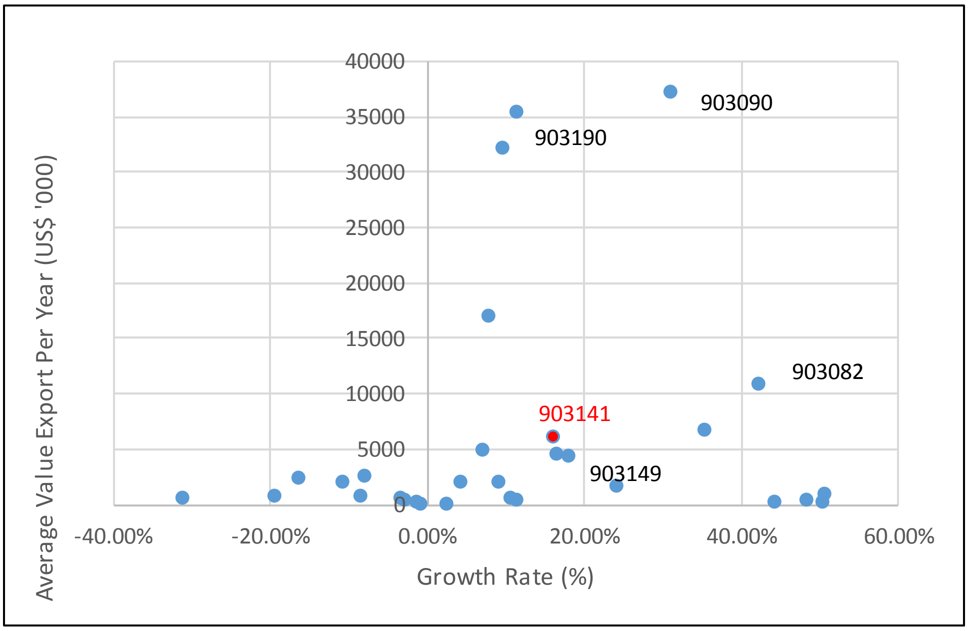
The RCA score for these two product codes (HS 903082 and HS 903141) coincides with the rise of Malaysia's SEM industry. For example, Penang Vision was incorporated in 2000 and Aemulus was started in 2004. Although HS code 903141 for optical vision for semiconductor inspection machines has an RCA score close to 1 for some years such as 2009 (RCA=0.99) and 2013 (RCA=0.96), its contribution HS 903141 may be understated, as these machines are also incorporated into a test handler machine which falls under HS 903082 (Corporation B, 2008). Technical overlaps of product codes aside, the big picture is Malaysia's breakthrough with SEM machines under the HS 9030 and HS 9031 product category, confirming interviewees' statements that Malaysia has upgraded its semiconductor testing machine value chain.

c) *Case Study: Optical Instruments for Semiconductor Wafer Inspection Machine with Reference to Penang Vision Malaysia*

Next, I explore whether Malaysia's SEM industry has been aided by China's additional demand and whether other factors would have caused exports of Malaysian semiconductor testing machines to rise anyway. Without claiming causality here, a case study is deployed in this chapter with trade statistics to see whether China has played a part in the rise of Malaysian SEM makers. Findings here are also verified against currency movements, and global demand for ICs.

The scatter plot in Figure 7.7 below visualises the Malaysia's 36 SEM products in terms of average value of exports per year (a size criterion), and growth rate (speed and potential of the product line). Malaysia's exports of semiconductor testing machines stand out in terms of both their average value and the growth rate compared to other SEM segments. HS codes 903141, 903190, 903090, and 903082 all indicate semiconductor test machines. Of products under these codes, I managed to interview Penang Vision, which specialises in optical instruments for semiconductor wafer inspection (HS code 903141), one of the most important SEM products in the test segment.

Figure 7.7 Scatter plot of Growth Rate and Average Value of Export per Year for Semiconductor Machinery Equipment 2002-2013



Note: 903141 (red dot) denotes optical instruments used to inspect semiconductors, the subject of the case study
Source: Own calculations based on UNComtrade

As shown in Figure 7.7, the export value of optical semiconductor inspection machines (HS code 903141) grew at 15.9% per annum from 2002-2013, faster than the SEM industry as a whole, which averages at 15.5% per annum. Penang Vision is in the optical machines for semiconductor inspection segment, whose products can be built into the semiconductor test handlers (HS 903082), and the trade data show rapid growth of optical instruments for semiconductor inspection products.

The RCA results are another reason for choosing optical semiconductor inspection machines as a case study. As shown in Table 7.6 below, the RCA jumps from a mere 0.20 in 2007 to 1.26 in 2008, moving Malaysia from no comparative advantage to a comparative advantage in producing optical machines for semiconductor inspection in 2008 in just a year.

Table 7.6 RCA of *Optical instruments & appliances for inspecting semiconductor wafers/devices/for inspecting photomasks/reticles used in manufacturing semiconductor devices* (HS 903141)

HS code	2005	2006	2007	2008	2009	2010	2011	2012
903141	0.11	0.25	0.20	1.26	0.99	1.03	1.70	0.96

Source: Own Calculations based on UNComtrade

The period 2006-2008 coincides with China tightening the implementation of the minimum wage (Huang et al. (2014). Huang et al. (2014) explain that legislation on the minimum wage was significantly tightened in 2004, with all provinces effectively setting their minimum wage and improving its enforcement by the end of 2007. China also restructured its minimum wage through its Labour Contract Law in 2008. However, with the global financial crisis in the same year, China relaxed the enforcement of the minimum wage in China (Huang et al., 2014) but firms had already placed orders for SEM in anticipation of the minimum wage rise. The relaxation of the minimum wage in 2008 coincided with the fall of Malaysia’s RCA for optical semiconductor inspection machines to 0.99 in 2009.

The sudden surge in demand for SEM from China is linked to China's move to increase the minimum wage for manufacturing workers in 2007. Manufacturers based in coastal areas in China, which had been used to cheap labour, suddenly faced increased labour costs. Some economic literature predicted that manufacturers would move inland in search of lower labour costs, but some manufacturers chose to automate the production line. So when labour costs rose in coastal areas of China SEM companies such as Malaysia's Penang Vision, exported exponentially more machines to China to meet the new demand.

Based on Huang et al.'s (2014) econometric results, employment in coastal area of China has an inverse relationship with the minimum wage: firms hire fewer employees as the minimum wage rises, and this relationship is statistically significant. Conversely, the minimum wage is positively correlated with fixed asset investment, with firms starting to buy more machinery as the minimum wage rises (Huang et al., 2014). This fixed asset investment purchase is also reflected in the data on Malaysia's exports of optical machines for semiconductor inspection to China.

Table 7.7 Malaysian Total Exports of Optical Instruments & Appliances for Inspecting Semiconductor Wafers/Devices/for Inspecting Photomasks/Reticles used in Manufacturing Semiconductor Devices (HS 903141)

Product Code	**HS 903141 (US$ bn)**
2002	0.04
2003	0.08
2004	0.06
2005	0.03
2006	0.07
2007	0.06
2008	0.23
2009	0.15
2010	0.37
2011	0.70
2012	0.39
2013	0.34

Source: UNComtrade

The trade data patterns in Table 7.7 above are consistent with the minimum wage in China affecting demand for Malaysian-made SEM. There is exponential growth of 270.5% from 2007-2008 in exports of optical instruments for inspecting semiconductor wafers or devices. The next step is to dissect the data to see which country the demand comes from.

Table 7.8 HS 903141 Malaysian Exports by Country (% to total exports)

Country	2006	2007	2008	2009	2010	2011	2012	2013
China	0.1	6.4	32.9	30.6	47.7	19.8	29.8	33.0
US	10.4	37.5	24.1	10.3	4.0	46.4	23.7	14.0
Singapore	6.9	18.0	15.6	31.2	22.2	9.9	9.3	9.3
Other Asia	44.4	2.2	9.1	0.7	4.0	11.5	15.7	15.6
Mexico	0.0	0.0	0.8	0.0	2.4	1.6	0.4	8.9
Hong Kong	9.4	8.6	1.3	0.0	8.9	2.6	3.0	6.5
Thailand	0.3	4.8	1.4	6.8	8.6	2.0	0.5	2.3
Philippines	0.4	6.4	2.6	1.3	0.2	0.5	7.1	5.7
Korea, Rep.	20.1	0.9	2.0	14.5	0.5	1.9	3.2	0.8
Japan	0.8	0.4	0.7	3.6	0.5	0.7	2.4	0.1
Others	7.2	14.8	9.5	1.1	1.0	3.2	5.0	4.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Own calculations based on UNComtrade

As shown in Table 7.8 above, China's share of total Malaysian exports of optical machines for semiconductor inspection leaped from a mere 6.4% in 2007 to 32.9% of total Malaysian exports in 2008, displacing the US, which was Malaysia's top importer of these products just a year earlier. The full table is available in Appendix 7.7.

The increase of demand from China does not replace demand from the US, and therefore it is unlikely to be caused by trade diversion. As Table 7.9 below shows, it is likely to be the result of organic growth in China, whose import demand of *Optical instr. & apps. for inspecting semiconductor wafers/devices/for inspecting photomasks/reticles used in manufacturing semiconductor devices* (HS 903141) increases from US$0.4 million in 2007 to US$7.6 million in 2008, while the US imports increases sharply from

US$2.4 million to US$5.6 million for the same product shows trade diversion is unlikely to be the reason for China's increased demand.

Table 7.9 Value of HS 903141 Malaysia's Export by Country

In US$ M	2006	2007	2008	2009	2010	2011	2012	2013
China	0.01	0.4	7.6	4.5	17.8	13.8	11.6	11.3
United States	0.7	2.4	5.6	1.5	1.5	32.4	9.2	4.8
Singapore	0.5	1.1	3.6	4.6	8.3	6.9	3.6	3.2
Other Asia, nes	3.1	0.1	2.1	0.1	1.5	8.1	6.1	5.3
Mexico	0.0	0.0	0.2	0.0	0.9	1.1	0.2	3.0
Hong Kong, China	0.7	0.5	0.3	0.0	3.3	1.8	1.1	2.2
Thailand	0.02	0.3	0.3	1.0	3.2	1.4	0.2	0.8
Philippines	0.03	0.4	0.6	0.2	0.1	0.3	2.8	1.9
Korea, Rep.	1.4	0.1	0.5	2.1	0.2	1.3	1.2	0.3
Japan	0.1	0.0	0.2	0.5	0.2	0.5	0.9	0.03
Brazil	0.0	0.0	0.2	0.0	0.0	0.8	0.0	0.5
Others	0.5	0.9	2.1	0.2	0.4	1.4	1.9	0.9
Total	7.0	6.3	23.3	14.8	37.4	69.9	38.9	34.2

Source: UNComtrade

To verify the results, a check of whether the currency movement biased the semiconductor test equipment trade results upwards was conducted. When the value of a country's currency falls against the US dollar, its exports become cheaper relative to other countries, assuming other countries are holding the value of their currency. In Malaysia's case, the year of interest to us in semiconductor equipment manufacturing is 2007-2008, where there is a one-off huge jump in equipment sold to China.

As shown in Table 7.10 below, 2008, when there is a sharp increase in exports of optical instruments for semiconductor wafer inspection to China, is a year when the value of the Malaysian Ringgit is stable. The average value of 1 Malaysian Ringgit against 1 USD is RM 3.44 in 2007, rising to RM 3.33 in 2008 (fewer Ringgits required to purchase US dollars). Therefore currency movement is an unlikely factor that biases Malaysia's sales of semiconductor testing equipment upwards in 2008. This strengthens the case that the increase in Malaysia's semiconductor testing equipment export value is not biased upwards by currency movement.

Table 7.10 Malaysian' Ringgit vs. US Dollar Exchange Rate 2002-2013

Year	RM/USD
2002	3.80
2003	3.80
2004	3.80
2005	3.79
2006	3.67
2007	3.44
2008	3.33
2009	3.52
2010	3.22
2011	3.06
2012	3.09
2013	3.15

Source: Economic Planning Unit, Malaysia

In contrast, China's Renminbi appreciated against Malaysia's Ringgit by 6.19% in 2008 compared to 2007. Table 7.11 below shows the RMB appreciating against Malaysia's Ringgit from 0.45 in 2007 to 0.48 in 2008. The slight appreciation in the RMB means that Chinese producers can purchase SEM equipment relatively cheaper in 2008 than in 2007. While the magnitude of change is not significant in ruling out rising demand from China helping to create new opportunities for Malaysia's SEM due to the currency effect, a rising RMB nevertheless does help to make Malaysian SEM exports more accessible to producers in China in 2008.

Table 7.11 Ringgit vs. Renminbi Exchange Rate, 2002-2013

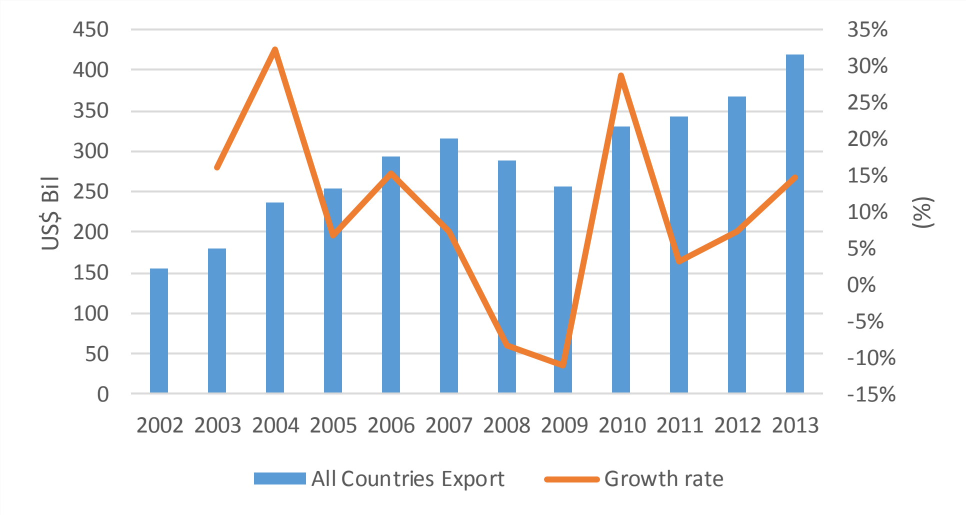
Year	Average	Rate of Change (%)
2002	0.46	-
2003	0.46	-0.02
2004	0.46	0.02
2005	0.46	0.68
2006	0.46	-0.53
2007	0.45	-1.73
2008	0.48	6.19
2009	0.52	7.51
2010	0.48	-7.77
2011	0.47	-0.50
2012	0.49	3.37
2013	0.51	3.97

Source: www.oanda.com, Accessed on 1 September 2015

Next, a check is made to ascertain whether overall demand in the global semiconductor delivery is responsible for the increase in Malaysia's exports of optical instruments for semiconductor wafer inspection in 2008. If this is true, demand for optical instruments (HS 903141) used in semiconductor wafer inspection will increase anyway due to a global surge in demand, as chip makers need more testing equipment to cope with the surge in delivery.

As shown in Figure 7.8 below, the sudden growth of Malaysia's optical instruments for semiconductor wafer inspection is unlikely to be buoyed by global demand because the global semiconductor industry contracts in 2007-2009. The semiconductor industry recorded negative growth in 2008 at -8.2% and -11.0% for 2009 compared to the year before according to *Electronic integrated circuits and microassemblies* (HS 8542) export data from UNComtrade. As secondary verification, SEMI®, a global association of silicon-based product manufacturers that tracks shipments of semiconductors confirms 2007-2009 as a period of decline.[102] Therefore based on these data from UNComtrade and SEMI, the surge in demand from China for Malaysian-made optical instruments for semiconductor inspection is unlikely to be the result of rising demand for global semiconductors.[103]

Figure 7.8 Global Export of Semiconductors HS8542 and Growth Rates



Source: UNComtrade

Finally, field interviews in Penang revealed that China had a direct positive impact on Penang Vision Malaysia's export market. When China raised its minimum wage in coastal areas, where most of its semiconductor industry is located, Chinese firms automated their production lines in a massive way. As a result Penang Vision sold more optical inspection machines than before, with exponential growth in revenue from 2006 onwards, as shown in Table 7.12 below.

[102] See full SEMI table in Appendix 7.8.
[103] A widely accepted semiconductor industry report, supported by semiconductor players themselves.

Table 7.12 Penang Vision Corporation Berhad Consolidated Revenue 2005-2013

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Revenue RM mil	9.1	24.0	36.2	26.4	18.1	87.6	79.2	88.9	106.1
Revenue US$ mil	2.4	6.5	10.5	7.9	5.2	27.2	25.9	28.8	33.7

Mil=million

Source: Penang Vision Corporation Berhad Annual Report (multi-years)

The case study confirms that China has a direct positive impact on Penang Vision Malaysia in its exports market demand. Penang Vision's annual corporate reports show that China has created additional demand for Malaysian-made optical instruments semiconductor wafer inspection machine. This case study also presents the findings based on trade data and then elaborates on the reason for additional demand from China especially for semiconductor wafer inspection machines.

7.3.3 Revisiting some of the theories with the Penang case

Having shown that China's effect on Malaysia's SEM players is complementary, the Malaysian SEM players' evolution can inform other branches of economics such as economic geography, spin-off theory and spatial embeddedness. I start to explain the formation and growth of SEM players in Penang through the lens of economic geography.

Although the strength of SEM clusters in testing and assembly machines are explained by GVC in E&E extended to backward linkages, it is limited in its explanation of how the SEM players formed and upgraded. Rajah Rasiah, an authoritative commentator on Malaysia's E&E industry, observes that GVC as a theory is limited in explaining South Korea and Taiwan's upgrading of their IC chip production capacity to become world-class leading manufacturers.

To address this gap, Grunsven (2006) argues that there is an evolutionary element to the second phase of Malaysia's E&E industry growth, starting in 2000, with the growth of Penang's automation clusters, including non-E&E components, fitting spin-off theory. The paper refers to Klepper's method of distinguishing between 'branching' companies compared to 'De Novo' companies, with De Novo companies outperforming branching companies in the long run (Klepper, 2002). Branching companies are companies that enter the industry through another related industry, such as a company already supplies jigs and fixtures and supplying high-precision parts to MNCs that decides to venture into building semiconductor test machines. De Novo companies are started by employees who learn about the industry working for MNCs and then leave to create spin-offs. As mentioned, a classic example of this is the founders of Intel, who were once employees of Fairchild Semiconductor, where they learnt about the industry and then decided to quit to formed Intel, creating a spin-off (Grunsven, 2006).

Grunsven (2006) application of spin-off analysis to explain the growth of Penang's SEM players is right to a certain extent. Table 7.13 below shows that most SEM companies are De Novo firms with founders who are ex-MNC employees. This fits spin-off theory: that MNCs are agents for the diffusion of technology in the local economy.

Table 7.13 Entry Mode and Relationship of Founders with MNCs for SEM Players in Penang

Companies	Year Founded	Founder/Co-founder	Ex-employees of MNCs	Entry Mode
Pentamaster Corporation Bhd.	1991	Chua Choon Bin	Intel Technology (Penang)	De Novo
SRM	1996	Sim Ah Yoong	HP Penang	De Novo
TT Vision	2001	Goon Koon Yin	Motorola Technology Malaysia (Penang)	De Novo
Aemulus	2004	Ng Sang Beng	Altera Penang	De Novo
EXIS Seremban	2002	Lee Heng Lee	An American MNC *	De Novo: started by upgrading OEM machine and now manufactures own machines
Penang Vision Corp Bhd.	2000	Chu Jenn Weng	HP Penang	-
MMS Ventures Bhd	1997	Sia Teik Keat	National Semiconductor	Diversifier
Inari Bhd **	2005	Dr. Tan/PG Ho	HP Penang	-

Note:* based on Exis Tech Sdn. Bhd. (2015).
**Inari Bhd. is an EMS, not a SEM player, but uses SEM machines.

Source: Grunsven (2006) and various annual reports.

As shown in Table 7.13, above, Michael Peterson and HL Lee, the co-founders of Exis Tech in Seremban, started the company in 2002 after they were offered the Voluntary Separation Scheme (VSS) by an American MNC. The Exis Tech case is an example of the economic down-cycle prompts local Malaysian to form local firms and this is further discussed in Chapter 8, when I discussed the founding of Inari Bhd.

However, there is an exception to Grunsven (2006) conclusion that ‘spin-offs’ aptly describes Penang’s second phase of development beginning in 2000, especially in SEM, and this is the case of Penang Vision, the biggest player in SEM by revenue. An interview with the co-founder of Penang Vision, who previously worked for an MNC, found that his technical knowledge of machine vision did not originate from the MNC, as he claimed to have had prior knowledge of programming machine vision, as it happened to be his final year project as an engineering undergraduate at Science University of Malaysia in Penang. Secondly, while working for HP he was offered a team to lead research into machine vision, but decided to quit and started his own company in 2000 with an ex-university colleague (interviewee 10). Therefore the technical knowledge did not flow from HP to its employee but the co-founder of Penang Vision already possesses the technical knowledge beforehand. This brings us to the next theory: spatial embeddedness.

The Penang SEM players' case demonstrates that spin-offs explain the path to development up to a certain point. For Penang Vision Corporation, spatial embeddedness does matter. The theory argues that location matters, as in the case of Silicon Valley which developed with its skilled workers and embedded computer industry know-how (B Asheim and M Gertler, 2005). Recently questions have been raised about whether spatial embeddedness is still relevant given the rise of GVCs, and other forms or 'organisational or relational proximity' (as in GVC), challenging the relevance of physical location (Pietrobelli and Rabellotti, 2012, pp. 241.). Indeed, for Penang Vision spatial embeddedness seems more important than spin-offs or backward linkages in explaining the high growth company. With most SEM firms are clustered in Penang State, the SEM case reinforces the suggestion that tacit knowledge is mostly grounded in one location, demonstrating that spatial embeddedness is still relevant in explaining the path to development.

Spatial embeddedness theory, which is discussed in the regional innovation system group of literature, explains that the technology is 'sticky' because workers that have the 'right' skills normally converge in only a few places. Embeddedness also features as an important concept of GPN theory. While it started as an outpost for outsourcing and subsidiaries of electronics MNCs, Penang began to display upgrading of its backward linkages, especially in SEM. For Inari Bhd, the 'Penang Network' concept cannot be replicated outside Penang. This suggests that spatial embeddedness is a suitable theory to explain the success of Penang's locally-owned players upgrading. Location as a factor is further reinforced by the interview data: Avago Technologies Sdn. Bhd. mentioned that Inari had won the outsourcing job mainly because physical proximity mattered to the principal technology holder (more details in Chapter 8).

Notwithstanding the importance of spatial embeddedness for explaining Penang Vision Corporation's achievements, the spin-off element cannot be completely dismissed, given the fact that Penang Vision's very first business order was related to the co-founder's previous employment with an MNCs (Grunsven, 2006). Secondly, although the Penang Vision's co-founder did not acquire technical knowledge while working for an MNC, he could have gained non-technical knowledge such as management and operations knowledge of a MNC. Finally, the two divisions that HP exited in 2008, Advanced Optical Inspection (AOI) and Advanced X-Ray Division (AXI), were bought by Penang Vision, which rehired the engineers working in this two divisions. This represents a transfer of knowledge and skills, aptly described as a spin-off, with ex-MNC employees joining a locally owned company. This shows that even within Penang Vision Corporation itself, different theoretical frameworks capture different stages of development of the company itself.

In conclusion, no single theory can explain the formation and growth of the SEM cluster in Malaysia entirely. The GVC/GPN and backward linkages can explain the broad sectors on which SEM is focusing, namely the testing segment, due to traditional demand from MNCs in Penang in this particular segment of IC production. However, for the second stage, formation and growth, spin-off theory can explain how a company obtained its technical know-how before entering the SEM cluster, but again becomes limited as a theory in explaining how the best performer in the semiconductor test segment grew. Penang Vision Corporation obtained its technical knowledge to design machine vision through its co-founders. Spatial embeddedness is the most suitable theory to explain, as Penang Vision started between two university colleagues in Penang. This, however, explains the beginnings of Penang Vision, as spin-off theory does help to explain the high growth of Penang Vision, given that it acquired the two divisions related to machine vision from HP, and the skilled engineers from the MNC.

7.4 Conclusion

This chapter has discussed how according to findings on the SEM industry Malaysia's role has shifted away from being just a low-cost centre for foreign MNCs' IC packaging operations for in 1970s. Once the backward linkage to the semiconductor industry is considered, Malaysia has upgraded its SEM value chain with special reference to the testing segment of the back-end of semiconductor industry. This has been achieved despite various criticisms of the MNC-led development model, which argues that the presence of MNCs squeezes out locally-owned small and medium industries, preventing their access to quality engineers. Related to this, the next chapter further explores how China's 'diversion' effect on investment has had the unintended consequence of creating a window of opportunity for local Malaysian start-ups.

Secondly, China's rise aided Malaysia's semiconductor wafer inspection industry (seven products) in 2002-2013 while the rest of the SEM industry's trade balance remained largely negative. The chapter then concentrated on the semiconductor testing segment to detail the upgrading of an industry, and investigated how China's pressure on implementation of the minimum wage in its coastal areas increased demand for Malaysian-made semiconductor wafer inspection machines.

The shift in labour costs in China led many scholars to predict that firms would eventually move either to inland China or back to Southeast Asia in search of lower costs. The case study in this chapter has demonstrated that firms stationed in coastal areas of China also had another option: to reduce labour costs by investing in automation. As a result, Malaysia has benefited from selling its semiconductor wafer inspection machines to China.

Apart from its backward linkages, the upgrading of Malaysia's SEM value chain also informs other theories such as spin-off and spatial embeddedness, as no one theory can completely explain all the phases of growth in the Malaysian SEM cluster. Finally, it is interesting to note that the literature on spatial embeddedness, which preceded the GVC in explaining the path of development, remains relevant to Penang's SEM development.

This chapter forms a contrast to Kaplinsky (2010) value chain case study of Thai Cassava and Gabon timber which, although unrelated to the semiconductor industry, found that China's increased demand for primary commodity exports actually downgraded the entire value chain in Thailand and Gabon. In contrast, China's demand has helped Malaysian-owned SEM players to move up the value chain with its demand for high-technology capital goods. In this sense, the effect of China's rise complements that of Malaysia.

A final point on SEM relates to work by Malaysian scholars such as Alavi (2002), which states that export oriented industries (EOI) such as electronics are not linked to the local industrial structure, creating a dual structure in the economy's manufacturing sector in Malaysia because there is little participation of local companies in the semiconductor value chain. Although the majority of direct semiconductor industry inputs are imported, the chapter has looked beyond direct inputs to consider SEM, elaborating on the spillover effect of EOIs locating in Malaysia, with their ex-employees leaving to create SEM spinoffs in Penang. Finally, Malaysian policymakers should note this SEM sector has the potential to help Malaysia ride on China's semiconductor boom without competing with China head-on.

8.0 Malaysia's E&E investment in China, Chinese operations in Malaysia and the 'China Effect' on Malaysia's E&E investment

As discussed in the literature review and trade chapters, Malaysia's trade structure is closely linked to its FDI, and this trade-investment nexus is prevalent in Malaysia's E&E industry (Wong and Tang, 2007). Chapter 6 also revealed that China competes with Malaysia for exports to destination markets. It is crucial to weigh the loss of export with FDI flows to see if China is mitigating the competitive threat in trade by investing in Malaysia's E&E industry. The objective of this chapter is to dissect the bilateral FDI flow between China and Malaysia, and then examine whether China has indeed diverted FDI from traditional sources such as the US, the EU and Japan away from Malaysia.

As the literature review chapter showed, quantitative studies based on regression models such as Chantasasawat et al. (2004), Zhou and Lall (2005), Eichengreen and Tong (2007) and Salike (2010) differ in their findings on whether China is has diverted FDI inflow from its East Asian neighbours. Zhou and Lall (2005) reason that a running regression using total FDI figures does not take into account the fact that total FDI figures can be misleading because they do not distinguish between FDI in competing export-oriented industries such as electronics, and FDI in non-competing areas such as markets and resource-seeking.

This chapter presents findings on investment in Malaysia's E&E industry in a more discernible way based on a combination of Asian Drivers literature and the GVC/GPN frameworks. The Asian Drivers literature (IDS, 2006) predicts that China will increasingly impacts the world in investment channels, and this chapter discusses the impact of China on a developing country such as Malaysia for the E&E industry. The chapter incorporates the approach of GVC/GPN studies of the spread of the electronics industry from advanced nations to developing countries and the upgrading of the value chain. These frameworks are used to discuss China's impact on Malaysia, Malaysia's shifting role in the GVC/GPN chain, and its upgrading, amongst other issues. Semi-structured interviews were used to collect primary data, which was compared with a secondary database of production data.

Based on the Asian Drivers literature and the GVC framework, and taking Malaysia as the reference point, there are three possible ways in which China can impact Malaysia's investment channel:

- China invests in Malaysia's E&E industry (FDI inflow to Malaysia)
- Malaysia invests in China's E&E industry (outward investment from Malaysia)
- China diverts investment from or encourages more investment in Malaysia from traditional FDI partners such as the US, EU and Japan.

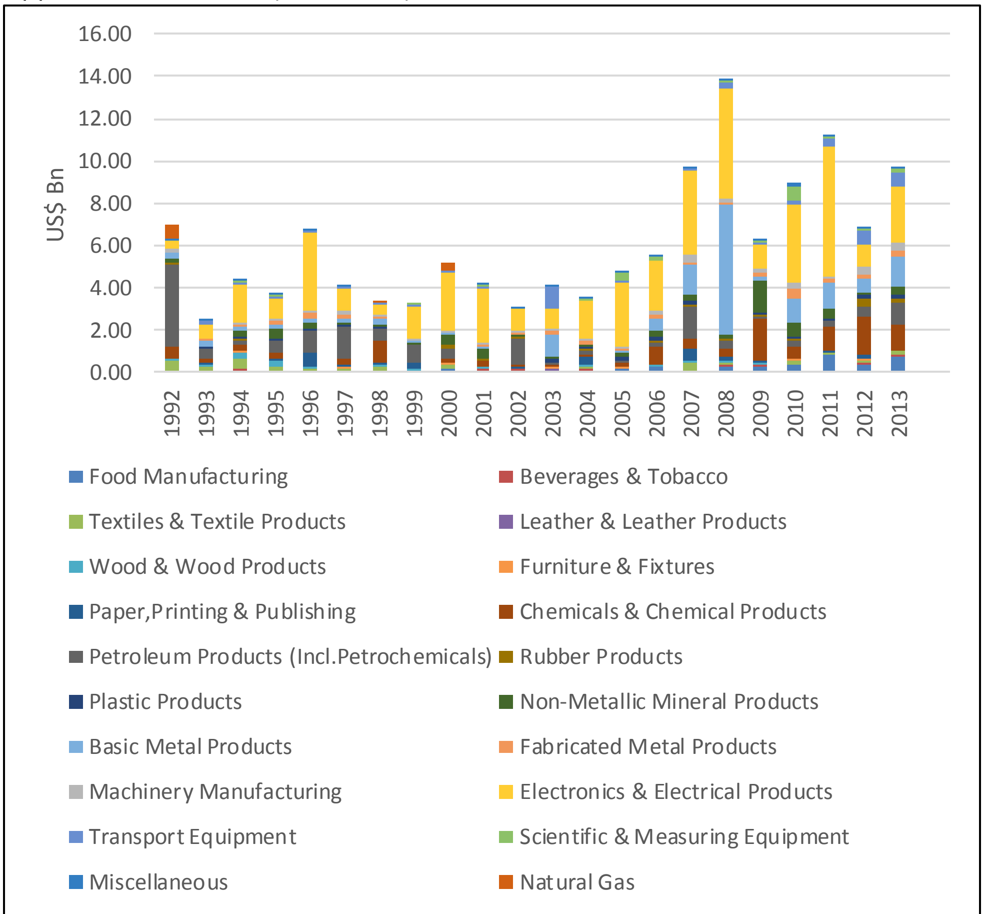
Based on the three possible impacts above, the research questions addressed in this chapter are:

- Does the bilateral investment flow reflect complementary sub-sector investment, and what are the drivers of Chinese FDI in Malaysia? Which sub-sectors are Malaysian E&E firms entering in China?
- Which Malaysian E&E sub-sector is affected by China's diversion of investment away from it, and what is the effect on the Malaysian E&E sector?

- How do Malaysia's firms and public sector respond to China's rise as an investment destination?[104]

The rest of the chapter presents a discussion of Chinese investment in Malaysia's E&E sector, followed by discussion of Malaysia's outward FDI to China's E&E, and whether China has diverted investment from Malaysia's traditional sources such as the US, the EU and Japan. The chapter ends with Malaysia's response to China's competition for investment in the region and concludes that China has both positive and negative effects on Malaysia via the investment channel and that its diversion of investment can also create opportunities for Malaysia.

Figure 8.1 Malaysia's Inward FDI for Manufacturing Sector by Type of Industry Approved Investment (1992-2013)



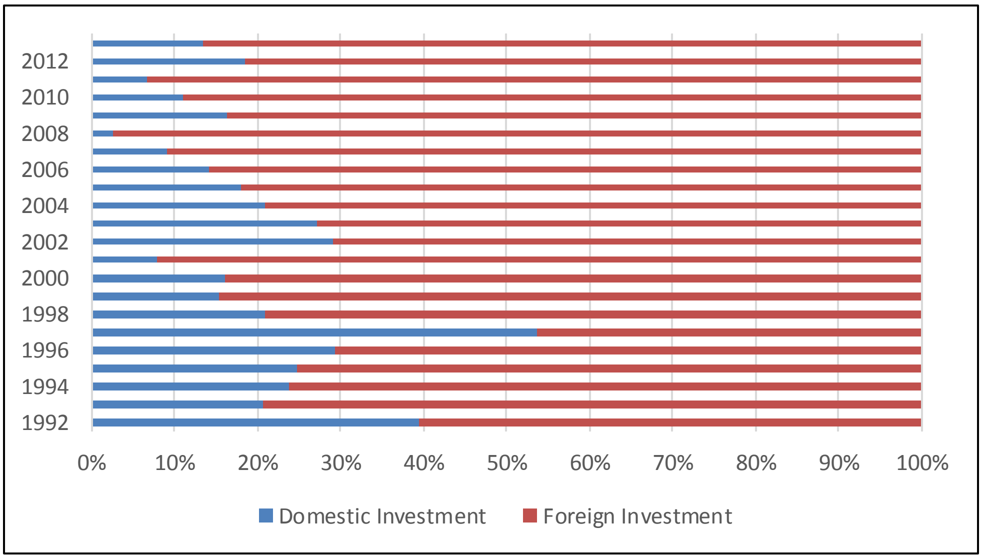
Source: MIDA

[104] Given the Malaysia trade-investment nexus, Malaysian government programmes discussed in this investment chapter also target increasing exports in the trade channel.

The chapter begins with descriptive Malaysian investment data for 1992-2013. As shown in Figure 8.1 above, the E&E sector is a major source of FDI in Malaysia in 1992-2013, with an average share of 39.7% of total FDI inflow, based on approved investment data. Cumulatively, investment in E&E is recorded as US$48.5 billion for 1992-2013, with basic metal products a far second at US$15.7 billion and petroleum products third at US$15.1 billion. The E&E sector is the most important source of manufacturing-sector FDI in Malaysia.

Foreign investment far exceeds domestic investment as a source of capital formation in the E&E sector. In 1992-2013 an average of 80.1% of total investment in manufacturing is from foreign sources, while the average share of domestic investment is 19.9%, as shown in Figure 8.2 below. Malaysia's E&E industry is characterized by heavy foreign investment of both capital and technology. The investment structure by source observes that the development of Malaysia's E&E industry is FDI-dependent (Ernst, 2004) and (Siew-Yean, 2001).

Figure 8.2 Share of Domestic AND Foreign Investment in Malaysian E&E



Source: MIDA

Malaysia’s E&E industry is characterized by a heavy presence of foreign FDI consistent with the country’s role as host to many of MNC operations, as reflected in the trade chapter. As a result, E&E is heavily traded between China and Malaysia, and between Malaysia and its traditional markets such as the US, the EU and Japan.

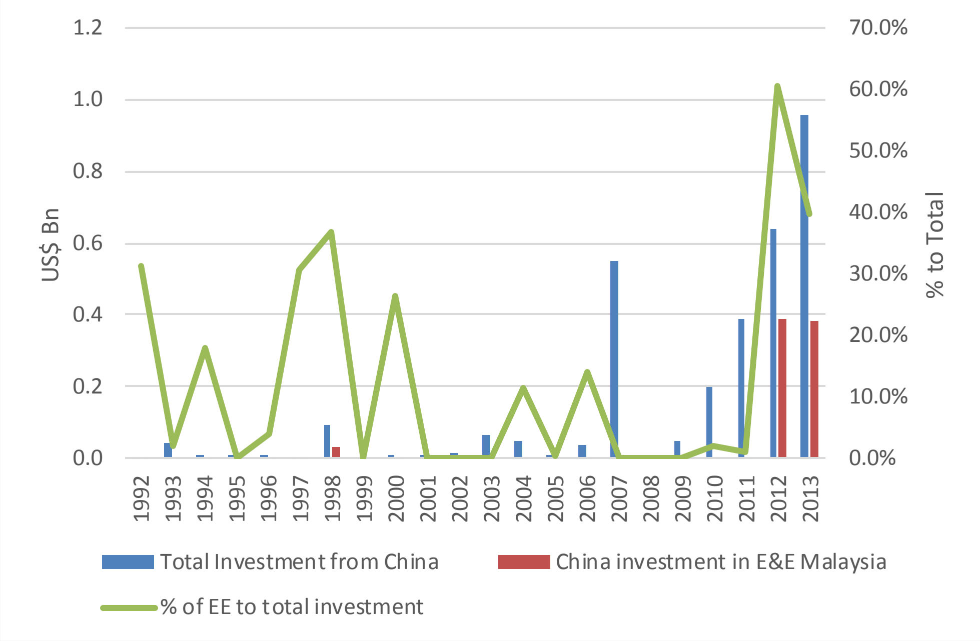
8.1 China’s investment in Malaysia’s E&E sector

This section elaborates on the first aspect of China’s impact on Malaysia; namely FDI inflow from China. The section is organised as follows: the volume of investment is presented next, followed by three cases of investment by China: services-related investment in Huawei, which is included despite being outside the scope of manufacturing as Huawei is a telecommunication equipment giant and mobile phone maker; in Comtec China in the manufacturing sector; and in trading of electrical products, Midea-Scott & English Electronics, with Midea of China enters into a JV with a Malaysian company to distribute its products in Malaysia. The section finds that Chinese investment in Malaysia’s E&E is limited, and that it is in its infancy.

While China has been Malaysia’s main trade partner based on volume since 2009, as discussed in the trade chapter, the scenario regarding investment is very different. As shown in Figure 8.3, below, total investment from China picks up from 2007 onwards, excluding the slump year in 2008. In 2007 the inflow of FDI from China amounts to US$0.5 billion but is not related to the E&E industry. Investment in E&E only picks up from 2012 onwards, and mainly in the electrical sector’s solar module value chain. China’s investment in Malaysia’s E&E sector only becomes sizeable from

2012 onwards: it invests US$0.4 billion or 60.7% of its total investment in Malaysia in 2012, and US$0.4 billion or 39.8% in 2013.

Figure 8.3 E&E Share of Total Chinese FDI in Manufacturing Sector of Malaysia

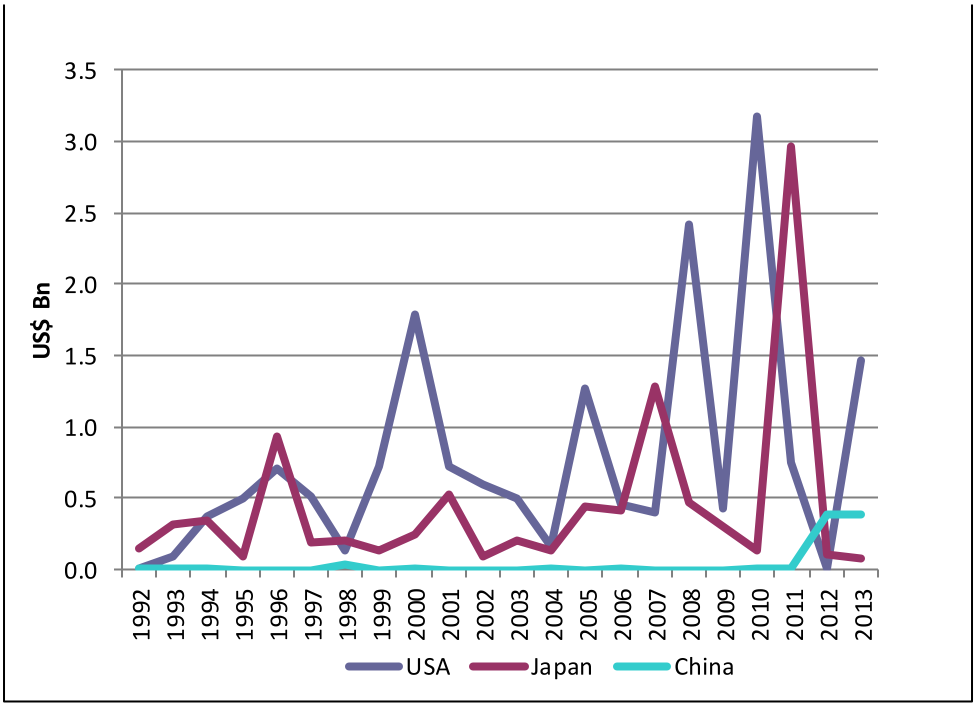


Source: MIDA

The volume of China's investment in Malaysia's E&E sector is far behind that of Malaysia's traditional sources of FDI such as the US and Japan. Chinese investment in E&E in Malaysia only inches up to US$0.4 billion in 2012[105] and 2013 having previously been close to zero (see Figure 8.4 below). In contrast, the US invests on average US$ 0.8 billion a year and Japan invests on average US$ 0.4 billion a year in 1992-2013. However, China is still in the early stage of investing abroad and the increasing volume from 2012 may be a sign that Chinese firms are beginning to venture abroad.

[105] Investment in 2012, based on US$0.39 billion, is most probably from EQ Solar of China, but the project has not taken off. (Sarif, 2010)

Figure 8.4 FDI Inflows for Malaysia E&E Sector by Selected Country of Origin (Approved Investment)



Source: MIDA

As shown in Figure 8.4, The inflow of investment in Malaysia's E&E from China is minimal compared to Malaysia's traditional sources of FDI in E&E such as the US and Japan. For example, the US is the top investor in Malaysia across the entire period 1992-2013 at US$17.1 billion, followed by Japan, US$9.7 billion, and Singapore, US$5.2 billion. China's cumulative approved investment in the E&E sector in Malaysia comes in far behind at US$0.8 billion, the volume of its investment only picking up in 2012. Based on volume of inward investment, China's impact in Malaysia's E&E sector via investment is minimal.

Structurally, MIDA investment approval data also show that of the electronic and electrical sector, electronics is the main contributor to E&E sector. However, there is an upsurge after 2011 in the electrical sector, mainly driven by Malaysia entering the solar photovoltaic module value chain. Finally, when the electronics sector is broken down into sub-sectors, namely components, consumer electronics, and industrial electronics, components prove to be the most important sector by volume of FDI inflow to the electronics sub-sector.[106] The investment data is reflective of Malaysia's specialisation in the parts and components market; the investment structure here is consistent with the trade specialisation. Details can be found in Appendix 8.1.

As MIDA data is at E&E aggregate level and it is MIDA policy not to discuss the figures at the individual firm level, secondary data is triangulated using Malaysian news report to locate the sub-sector and stage of production in the E&E value chain in which China is investing. As MIDA investment data are based on approval data, there is a possibility that approved investment does not go on to the implementation stage due to various reasons. Data obtained from newspaper sources sometimes do not exactly match figures provided by MIDA, but because Chinese investment is relatively new and has gone to very few projects, and major FDI deals are publicised by MIDA, it is not hard to identify FDI project inflows from China.

Based on triangulation of secondary sources with approved investment figures, of all the different E&E sub-sectors, Chinese investment matters most in the electrical sub-sector. MIDA's Investment Performance Report reveals that 'In 2013, the most significant solar projects approved are all foreign-owned, including … a RM1.2 billion facility to manufacture solar silicon ingots and wafers.' (MIDA Malaysia, 2013, p. 38) This matches news reports of E&E investment in Malaysia: there are two notable Chinese projects, Comtec China and Huawei China. Comtec produces silicon ingot and wafers for solar photovoltaic modules, while Huawei is a famous

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[106] Examples given by MIDA of its Electronics classification include components such as semiconductors, consumer electronics, such as TVs and radios and industrial electronics such as computers.

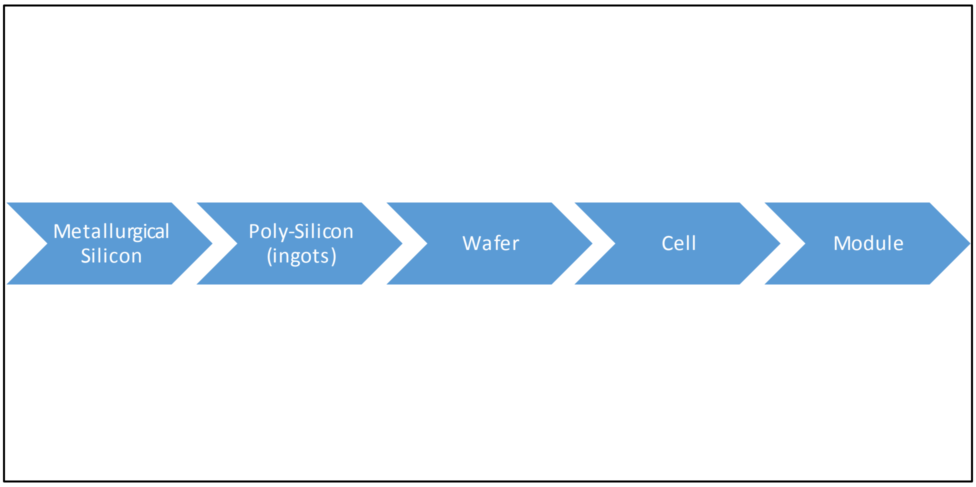
telecommunications equipment supplier and manufacturer. Comtec invested approximately RM1.2 billion (US$ 0.39 billion) in the state of Sarawak to produce silicon ingots and wafers in 2012 (The Borneo Post, 2012), while Huawei is reported to have invested RM430 million (US$ 136.5 million) in a cloud data centre in Iskandar, in the Malaysian state of Johor in 2013. [107] (CIMB Research, 2015).

Despite the fact that Huawei China's investment in Johor State is in data services such as hosting servers and cloud services, which are not manufacturing activity, it is included in this research because it is related to a China's telecommunications giant. Its data centre is expected to create 600 managerial and technical jobs (Khazanah Nasional Malaysia). However, it is the next investment from Huawei, also outside the manufacturing sector, that may help Malaysia onto the technology ladder. Huawei's first technical training centre outside China specializing in delivering sessions in English based in Cyberjaya, Malaysia for an undisclosed sum. It occupies 30,000 sq. ft. of office space and employs about 150 trainers with the capacity for training 2-3,000 students from China per year in 2015 (Asohan, 2012). Moreover, Huawei recently signed a Memorandum of Understanding between Huawei and Telekom Malaysia (TM), a government-owned telecom company, for joint R&D into copper connections and ZTE, another China's telecommunication giant also signed an MOU with TM for joint R&D into photonic and optical network research. Although Huawei's investment in Malaysia was initially only to host a data centre, it subsequently expanded into the creation of a training centre, which seems to fit Malaysia's view of upgrading technical knowledge through FDI.

[107] US$0.39 billion are converted to US$ using 2012 exchange rate US$1=RM3.0888. US$136.5 million is converted using conversion rate in 2013 is US$1=RM3.1509 provided by Malaysian central bank.

Moving back to the manufacturing sector, Chinese investment in Malaysia's E&E sector is efficiency-seeking. John Zhang Yi, the CEO of Comtec China, saw Sarawak as suitable for Comtec's plan because 'Although moving production lines to Malaysia is costly, ... this will be offset by lower power prices in hydropower rich eastern Malaysia, where electricity costs less than half that of coal fired power in Jiangsu. Electricity accounts for just under 20 per cent of Comtec's total operating costs' (Cave, 2014). The energy price factor, coupled with concern about US and EU imposition of countervailing duties on all Chinese- and Taiwanese-made solar PV modules has led Comtec to invest in Sarawak.

Figure 8.5 Malaysia's PV Value Chain



Source: Rahman et al. (2012)

Comtec is investing in Malaysia's solar photovoltaic module value chain as an upstream player in the PV production chain, namely at the silicone ingot and wafer stage. At full operation, the Sarawak plant achieves a capacity of 300 MW, and Comtec plans to achieve this by moving about 100 MW production capacity from China to Sarawak while the rest of the capacity is newly setup in Sarawak (Cave, 2014). Based on stages of production in the

PV value chain as in Figure 8.5, investment from Comtec China is less primary than another Japanese operations (Tokuyama) in the vicinity as Tokuyama produces silicone ingots to be sent back to Japan for further processing (Tokuyama Corporation, 2012). Although Comtec's investment produces high-efficiency mono-crystalline type solar wafers, which help Malaysia to further plug into the solar PV global value chain, the disadvantage of this investment is that it is still an upstream activity, with less spillover of technology, and R&D has not been mentioned in this investment.

Comtec's motivation is to use the clean energy generated by hydropower in Sarawak to produce silicone ingots and silicon wafers, underscoring how China's investment in E&E is efficiency-seeking. However, it is premature to conclude that China is degrading the value chain by investing in something upstream, in contrast to the case Thai Cassava value chain by Kaplinsky (2010), where Chinese demand for cassava starch exports although increases investment in the starch processing facilities in Thailand, the type of starch demanded was at a more primary level. As a result, investment was directed into primary sectors within the cassava value chain, and thus downgrading it. A Japanese investment in the state of Sarawak is running similar operations with production ending with the silicon ingots, which are sent back to Japan for further processing and added value. Based on this observation, firm-level operations from any country of origin could just possibly end up at the primary level, and this cannot be generalised to the whole of a single country's investment.

As Chinese investment is situated in the upstream stage of Malaysia's E&E manufacturing sector value chain and is low in volume relative to that of the US and Japan, China's impact on inward FDI to Malaysia is very limited.

Outside manufacturing sector investment, an international Chinese household electrical MNC has a joint venture with a Malaysian company that are principally involved in trading in household electrical products. Such a company are not known to receive any knowledge transfer from China and the investment is purely market-seeking. However, field interviews revealed that the Malaysian company benefits from working with a stable principal while the Chinese company is able to tap into the Malaysian company's local knowledge and marketing plans. Malaysian managers benefit from going regional through this JV, with the CEO of the Malaysian company also serving as an advisor to Midea China on its marketing strategy in the ASEAN region. The JV relationship allows the Malaysian company to benefit from the revenue stream generated by sales of imported Chinese household electrical goods. In contrast, established Korean and Japanese MNCs do not agree to such JV arrangements. Chinese imports are cannibalising the Korean and Japanese shares of the market for household electrical items, especially home-based air-conditioning, consistent with the import penetration analysis section in Chapter 5.

It is pertinent at this point to ask why Chinese firms do not invest heavily in Malaysian E&E. Respondents in China provided a view of Malaysia's investment prospects from the other side, pointing out that the market for Chinese consumer goods is low volume in Malaysia, given its comparatively small population in the ASEAN region. Based on market size, Indonesia seems more suitable for investing in a manufacturing plant. Chinese companies are more likely to invest in Vietnam due to its labour costs, which are lower than in China's coastal area and Malaysia. In addition, a Chinese firm's member of staff noted that Malaysia lacks human capital, which Chinese firms tap occasionally from Europe for higher R&D or product design functions.

In conclusion, China's investment in Malaysia's E&E industry is minimal based on relatively low volume of investment compared to Malaysia's traditional partners. China's investment is efficiency seeking and market seeking in the electrical sector. The type of FDI inflow for producing silicone ingots and wafer or the data centre has not generated the kind of positive technology spillover that North American, EU and Japanese investment has generated in the past. In the trading sector, the China-Malaysia JV investment is clearly market-seeking with the aim of building a sales channel for their electrical products. However, it must be remembered that China is relatively new to FDI compared to Malaysia's traditional sources.

Going forward, China's investment in Malaysia is starting to pick up. It is predominantly in the steel industry, reinvigorating unsuccessful state industrialisation projects such as Perwaja steel (Abilah, 2015), but this is beyond the scope of this thesis. Through official channels, China also has a joint industrial park with Malaysia on the east coast of Peninsular Malaysia called the Malaysia-China Kuantan Industrial Park, with Malaysia seeking about US$10.0 billion of Chinese investment over a 10-year period and a similar joint industrial park in Qinzhou Industrial Park in China (Khor, 2013). Despite this ambitious target, China's investment in Malaysia is still a long way behind its traditional sources of FDI in E&E, the US, Japan and Germany.

8.2 Malaysian investment in China's E&E sector

Malaysia's outward investment in China is higher than inward investment from China at total investment level. A detailed breakdown of investment by the sector is not publicly available, but according to the Malaysian Trade Minister, the ratio of bilateral FDI Malaysia-China flow is 6:1 (Yi et al., 2014). As the Central Bank of Malaysia data in Table 8.1 below, shows, in 2008 Malaysia's inward FDI from China based on balance of payment data is US$0.3 billion vs. its outward FDI to China of US$1.3 billion. Malaysia's investment in China rises to US$1.8 billion in 2013, but China's investment into Malaysia remains relatively unchanged at US$0.3 billion in 2013. However, the true outflow from Malaysia to China, based on official statistics, can be understated, as some entrepreneurs prefer to channel their funds via Hong Kong to be safer from a legal standpoint (Khor, 2013). Results in Table 8.1 confirm the Malaysian Trade Minister's observation that Malaysia invests more in China than the other way round. An alternative source of information is the UNCTAD's World Investment Report (WIR), available in Appendix 8.2, which does not alter this conclusion.

Table 8.1 Malaysia's Total Direct Investment Abroad (DIA) vs. China's Total FDI into Malaysia

Year	Malaysian DIA to China (US$ bn)	Chinese FDI in Malaysia (US$ bn)	Malaysian DIA over Chinese FDI ratio
2008	1.3	0.3	4
2009	1.3	0.2	7
2010	1.3	0.3	4
2011	1.9	0.4	5
2012	1.8	0.2	7
2013	1.8	0.3	5

Source: Own Calculation based on Central Bank of Malaysia Monthly Statistical Bulletin (May 2015)

The official investment outflow data are sketchy and are only available from 2008 onwards for total outflow in all sectors, but give us an idea of the size of the outflow. When Malaysia's Direct Investment Abroad (DIA) by sector is cross-checked, manufacturing is not the main sector in which Malaysian companies are investing abroad (at total level for all countries):

more volume is invested in mining and financial and retail. Furthermore Central Bank data is derived from the balance of payments and is thus more actual than MIDA's approved investment data.

There are currently no official data available about the number of Malaysian companies based in China. However, a 2003 survey carried out by Deloitte Kassim Chan, called the Malaysian Investment into China's Fitness Survey, and quoted in the IDE - JETRO and SERI (2004) report puts the number of Malaysian companies already in China at approximately 34 (21% of 160 firms surveyed in all sectors).[108]

Moving away from the Deloitte Kassim Chan survey which covers all sectors, I narrow down Malaysia's investment in China's E&E sector using secondary sources such as corporate annual reports filed with the Malaysian stock exchange. These are the reports of Malaysian Tier 1 and Tier 2 suppliers to MNCs in the E&E value chain which have invested mainly in EMS service or contracting manufacturing services in China. The Malaysian parent companies are medium-sized and publicly listed on the Malaysian bourse. The list of Malaysian companies, with geographical location in China with corresponding manufacturing activity is as follows:

- VS Electronics
    - Qingdao (Electronics Plastics) - plastic part moulding,
    - Zhuhai, Guangdong (EMS) - contract assembly of E&E products including telecommunications products

[108] IDE is Institute of Developing Economies, JETRO is Japan External Trade Organization, and SERI is Socio-Economic Research Institute, a research arm of Penang State Government.

- Carsem-Suzhou, China – IC testing and packaging[109]
- Unisem –Chengdu, China- IC testing and assembly[110]
- Inari-Amerton Kunshan, China- optoelectronics and fibre optics

With the exception of Amertron-Kunshan, which was acquired by the Inari Group using Mergers and Acquisition (M&A), the mode of entry for the rest was the creation of a subsidiary. However, China is not the only location outside Malaysia for the Malaysian companies listed here. For example, Inari-Amertron has manufacturing facilities in the Philippines, and Unisem also has facilities in Batam, Indonesia.

There are various reasons for Malaysian companies venturing into China. In the E&E industry, Malaysian investors in China are from the EMS segment, and the most plausible reasons are defensive market moves and efficiency-seeking (IDE - JETRO and SERI, 2004, pp. 15) note: 'Without doubt, some subcontractors are being "forced" by their customers, notably the multinational corporations (MNCs), to shift part of their production to China so that they could continue serving them', and to achieve 'tax savings and manoeuvrings around the Chinese government restrictions on licensing and distribution' (IDE - JETRO and SERI, 2004, pp. 15.). Other reasons include being able to tap into China's lower labour costs in the initial period, and being close to its huge market.

Although China's market is huge and full of potential, it is not without its challenges. Those faced by Malaysians investing in China include the high

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[109] Carsem is a Top 20 semiconductor assembly and testing company with 1.4% of total market share by revenue, or US$0.34 billion in 2014 (Gartner IC Insight Report 2014 in Nomura Research, 2014).
[110] Unisem is a Top 20 semiconductor assembly and testing company with 1.3% of total market share by revenue or US$ 0.31 billion in 2014 (Ibid).

cost of doing business (mostly due to administrative and policy issues), a higher inflation rate in coastal cities, the high turnover of workers, lack of intellectual property protection, and Chinese managers inadequate skills and poor command of English (IDE - JETRO and SERI, 2004). Companies that overcome all these obstacles still face very competitive costs in China.

Malaysian EMS players that overcome the challenges of operating in China benefit by diversifying into other areas of the E&E industry. VS Electronics, a world top 25 EMS provider that started operations in Shenzhen in 1997 and listed its business on Hong Kong Stock Exchange[111] in 2002, acquired Zhuhai Deyuan Energy Conservation Technology Co Ltd, a solar panel PV manufacturer in China, in 2015, which already has pre-orders for solar PV for buildings in China (Mahpar, 16 April 2015).[112] VS, which started as a supplier of plastic mould components and assembly of communication products and higher-end multimedia products faced a challenging situation in the assembly business in China recently and decided to branch out into manufacturing solar modules. This purchase by VS Electronics in China is an example of an opportunity for Malaysian companies seeking to move from the thin profit margin of contract manufacturing into other areas.

Conversely another Malaysian EMS, Globetronics, decided to pull out of China in 2009. Globetronics is a Penang-based contract manufacturer of ICs and LED. The reason it pulled is that most Malaysian E&E manufacturers are in the cost sensitive contract manufacturing business and the cost advantage in China has been eroded over the years. The cost of producing products in China is already equal to or above the cost of producing in Malaysia, coupled with high labour turnover, a shortage of labour in China

[111] VS Electronics main parent is listed in Malaysian bourse in Kuala Lumpur, while VS International is a subsidiary of VS Electronics and listed in Hong Kong Stock Exchange.
[112] EMS ranking is based on Manufacturing Market Insider 2014 report.

in coastal areas and frequent changes to China's policy and customs controls, all of which impose additional costs on producers. Since exiting China Globetronics has been doing well and has expanded in Malaysia (BFM 89.9 The Business Station Malaysia, 2014).

Complementarity factors due to China's rise shift for Malaysian E&E players over time. When it was a low-cost production base Malaysian EMS benefited and invested in China to tap into the low-cost labour, but when labour costs, especially in coastal areas, increased this type of complementarity disappeared and a new type arrived, namely rapid demand for automation. Semiconductor equipment manufacturers (SEM) in Penang, especially those in optical semiconductor inspection machines, benefit from this surge in demand from China.

In conclusion, China's impacts on Malaysian companies that invest in China are generally complementary. The complementary aspect itself changes with China at different phases of development. It began as a base for low-labour costs for EMS players, and recently offered opportunities for diversification with Malaysian companies acquiring Chinese companies in order to branch out into other E&E products. From 2008 onwards, when labour costs in coastal areas of China increased, Malaysian companies in backward linkages, such as SEM companies, benefited from the wave of automation in China's coastal cities. Invariably, Malaysian companies ability to adapt and change their strategy in China's very competitive market.

8.3 China's diversion of Investment in Malaysia from Malaysia's traditional partners

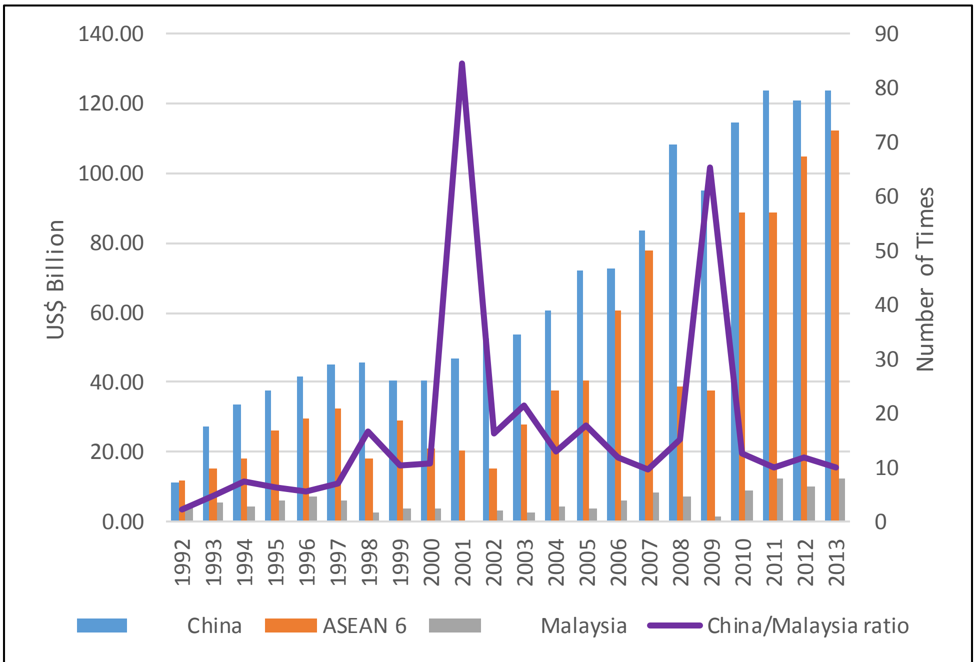
This section examines China's diversion of Malaysia's traditional partners' investment to itself. It uncovers the impact of China on the Malaysian E&E sector based on the volume of inward investment, production and employment data in Malaysia, the entry and exit of firms, and field interviews. The chapter then validates the findings with news report and government documents. As context the section presents case studies of Dell Computers' shift of production from Penang to China and of an audio product company that I visited in Dongguan China that previously had production lines in Penang. It also looks at mitigating factors in the diversion of FDI from Malaysia. The chapter concludes that the China effect is complex, with short term loss of jobs a common effect when MNCs move to China. Malaysia is upgrading its E&E industry through efforts on the part of the public and private sectors as a respond to China's rise.

One weakness of presenting case studies and employment figures in this section is the inability to claim causality. As the section will show, the issues are complex: some senior E&E managers in Penang pointed out that cost can be another driver for firms to relocate their plants and investment. This chapter elaborates on China's impact on Malaysia via the investment channel using sectoral labour data, matching it back to firms' entry to and exit from Penang. The current literature is either highly aggregated in econometric studies or a fully qualitative based case study. This section brings this sectoral data together with the case studies, validating them with field interviews.

Figure 8.6 and Table 8.2 present total FDI inflows for China and Malaysia to give an idea of the size of the inflow between Malaysia and China. ASEAN-6 is an aggregate of Singapore, Malaysia, Thailand, Indonesia, Philippines, and Brunei. Total investment inflow for Malaysia in 1992-2013 shows it lagging behind not only China but also ASEAN-6. FDI inflows into China grew on average by 16.9% per year, clearly outperforming Malaysia at 3.1% growth per year, while investment inflow into ASEAN-6 grows on average by 11.2% per year. In terms of growth rate, Malaysia's inward investment has underperformed compared to China and even ASEAN.

Based on the China/Malaysian FDI ratio (see Figure 8.6), the gap between Malaysian and Chinese FDI inflows are the widest in 2001 and 2009. This is not to claim causality between the two FDI inflows, but to get a general trend to focus the discussion. Incidentally 2001 was the year that China became a member of the WTO, and this is discussed in detail during the labour data presentation and Dell case studies. 2009 is impacted by low demand as a result of the global financial crisis, which started in 2008.

Figure 8.6 FDI Inflows into China, ASEAN-6 and Malaysia



Source: UNCTAD World Investment Report

Table 8.2 Malaysia and China FDI Inflow at Total Investment Level

	US$ bn					
	1992	1997	2002	2008	2013	Average 1992-2013
China	11.0	45.3	52.7	108.3	123.9	66.0
Malaysia	5.1	6.3	3.2	7.2	12.3	5.8

Source: UNCTAD World Investment Report

Next, I present the findings for this section. The main finding is that the 'Chinese effect' on Malaysia's E&E sector is a loss of jobs in the short term in certain sub-sectors, but overall total employment in E&E remains stable, suggesting the shifting of labour between sub-sectors reflects Malaysia's increasing specialisation in more sophisticated exports. Secondly, China complements the R&D structure of MNCs operating in multiple locations in East Asia. The chapter also elaborates on the impact on the supply chain of companies moving their production lines to China. This study finds that Malaysia is upgrading its E&E industry based on the pattern of entry and exit of firms in Penang and labour shifts across sub-sectors within the E&E industry.

The firm interviewed provided insights into MNCs that have invested in and then left Malaysia and firms with plants in both Malaysia and China, but not firms that could have invested in Malaysia but decided to invest in China instead. These findings are important, as China is often blamed for diverting investment but this chapter will show, it can have positive effects when a developing country reacts appropriately.

Most Malaysian managers interviewed concurred that the era of factories closing and moving from Malaysia to China around 2000-2005 has passed. This observation is consistent with Figure 8.6, which shows that Chinese, and Malaysian total FDI inflows increased the most in 2001. As data on how many E&E firms have left Malaysia or entered the E&E industry is not available at national level I used the Rietema and Velden (2013) database of firms' entry and exit in Penang state instead. As manufacturing contributes close to 50% of Penang state's GDP and is a major source of employment, Penang is a close representative of the E&E industry in Malaysia.

8.3.1 China's diversion effects in E&E industry of Penang State

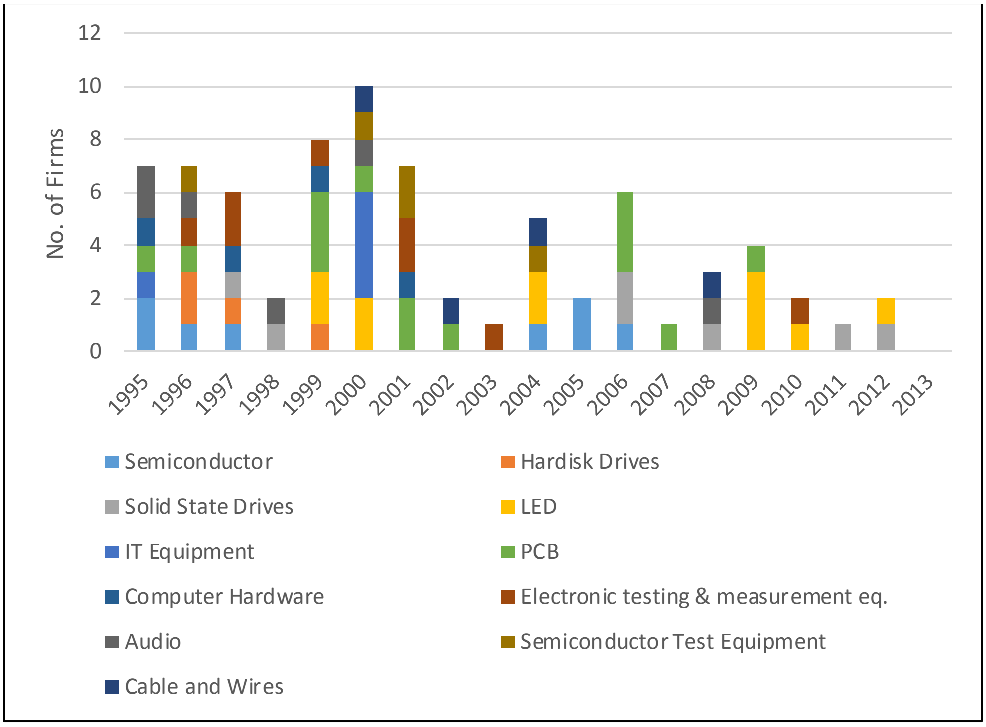
This section aims to discuss the China's diversion effects of investment in the Penang state, with the use of the Rietema and Velden (2013) database and draws on some employment data at national level where applicable. Rietema and Velden (2013) compiled a list of MNCs based on various sources including MIDA, JETRO, and InvestPenang to create a database on the E&E industry. The total number of MNCs in Penang in the database is 119 in 1994 increasing to 175 in 2013. The database divides the MNCs into various E&E sub-segments such as semiconductors, domestic appliances etc. These categories are included in this research, except for medical devices, which are beyond its scope.

The weakness of the database is that some entities have remained registered in Malaysia even after production had shifted away, as Rietema and Velden (2013) methods of recording their entry and exit is based on continuous registration of the business entity in Malaysia. For example the Taiwanese audio equipment company that I visited in Dongguan, China moved its production line there from Malaysia in the early 2000s, but only officially left from Penang in 2014 and was delisted from the Malaysian stock exchange in 2013. As some companies continue to be registered in Malaysia but move their main operations to China or elsewhere, this understates the number of firms exiting from Penang.[113]

The database is adjusted by adding the SEM players in Penang, and the results are shown in Figure 8.7 and Figure 8.8 below. Local SEM players are included to see whether the period of MNCs leaving Malaysia coincides with Malaysian-owned SEM start-ups in Penang, which was the subject of the discussion on upgrading in Chapter 7.

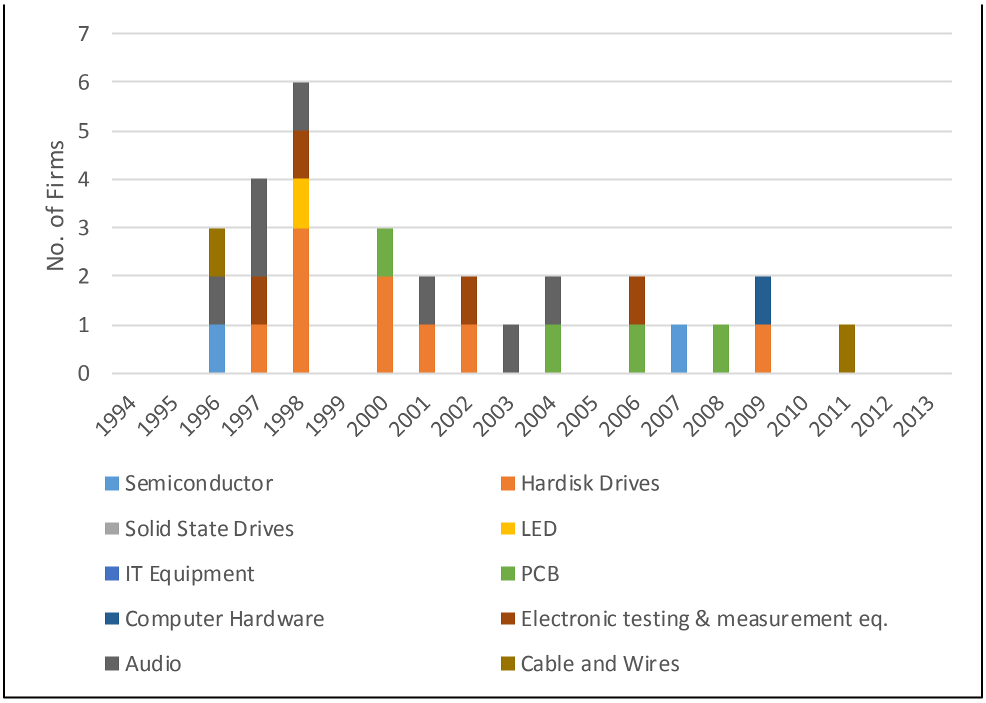
[113] This also partly explains why the number of firms is very different in Table 8.3.

Figure 8.7 Entry of E&E Firms in Penang



Source: Adjusted from Rietema and Velden (2013)

Figure 8.8 Exit of E&E Firms from Penang



Source: Adjusted from Rietema and Velden (2013)

Figure 8.7 and Figure 8.8 above show the peaks in MNCs leaving Penang in 1998 during the Asian Financial Crisis and of the entry of new firms in 2000. Interestingly, 1998-2000, just prior to China's entry into the WTO, sees an increase of firms leaving or beginning to shift their production lines to China in 2001. The number of firms exiting Penang in 2001-2002 is not significantly higher than in other years; and the number of firms entering Malaysia peaks a year before China joins the WTO, namely in 2000, and remains high in 2001.[114]

Importantly, locally owned SEM manufacturers were mostly set up in 2001-2002 and into the early decade of 2000, roughly during the period when firms were exiting Penang. Although some SEM players such as Pentamaster and SRM were started in 1991 and 1996 respectively, the majority of SEMs such as Penang Vision, TT Vision and Aemulus started in the early part of the decade of 2000. [115] The pattern of entry and exit of firms in Penang, particularly those entering after 2000, fit the view of a shift in industry with old assembly lines leaving Penang and a new industry being formed.

Apart from having MNCs leaving Malaysia around 2000-2005, Penang's economic census data in 2005 shows that branches of MNCs that commenced operations in Penang fell to a low of 23 firms in 2000-2004 from a peak of 63 in 1990-94 as in Table 8.3 below.

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[114] Dell's case study later in the chapter shows firms deciding to relocate even prior to China joining the WTO.

[115] Pentamaster manufactures semiconductor testing and inspection equipment and provides automation solutions for other manufacturing industries (Pentamaster, 2015).

Table 8.3 Branch Plants of Multinational Enterprises Operating in Penang, as at 2005

Commencement year	No. of firms	Gross output		Employment	
		RM million	%	Headcount	%
Pre-1970	8	1,054	1.5	3,452	3.6
1970-74	9	6,301	9.2	11,769	12.3
1975-79	5	215	0.3	1,061	1.1
1980-84	11	1,242	1.8	11,136	11.6
1985-89	52	7,873	11.6	23,454	24.4
1990-94	63	9,222	13.5	18,301	19.1
1995-99	32	40,435	59.4	21,273	22.2
2000-04	23	1,783	2.6	5,585	5.8
Total	203	68,125	100.0	96,031	100.0

Source: Malaysia Economic Census 2005, Unpublished Returns Compiled by Athukorala (2012, p. 26.)

Although this section predominantly has discussed China's effect on Penang State E&E industry via investment diversion, Table 8.4 show examples of major firms that have exited Malaysia at national level to further illustrate the types firms exiting from Malaysia. The majority of the firms listed in Table 8.4 are based in Penang prior to the exiting, except for JVC, Sanmina-SCI, STATs-ChipPAC and Panasonic TV.

Table 8.4 Examples of Firms Exiting Malaysia

Year	Name	Segment	No. of Empl. Aff'ted	Country of Origin	Notes
1997	Philips Audio	Audio Equipment	1,500	NL	Move to China
1998	Nikko Electronics	Consumer Electronics-radio controlled toys.	1,000	Malaysian	Closed down
2001	Seagate Technologies	Hard Disk Drives	4,000	US	Internal restructuring
2001	Aiwa	Audio Equipment	N.A.	Japan	N.A.

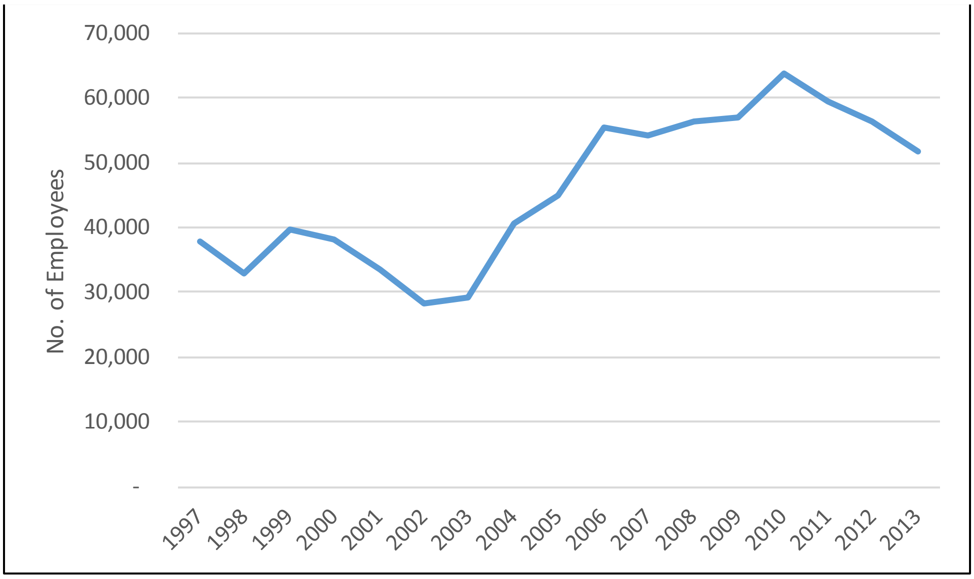
Year	Name	Segment	No. of Empl. Aff'ted	Country of Origin	Notes
2002	Sony Electronics in Penang (Formerly 3 subsidiaries of Sony. One of the subsidiaries is Sony Audio before 1998 restructuring, merge the 3 plants in Penang under one company.	Audio Equipment like Walkman.	N.A.	Japan	In 2002, VSS were to be offered to employees. Sony Malaysia is to focus on high value engineering products and move away from mass production.
2002	Iomega	Zip Drives	N.A.	US	Penang Plant sold to Ventures Group in Singapore, exit reason more towards change in technology, rather than China factor.
2009	Dell Computers	PC	700	US	Slashing costs
2009	NEC	PC	240	Japanese	Close due to low demand for its products
2009	Intel Malaysia	IC Chips	1000	Close test and assembly plant in Bayan Lepas Penang	Workers are moved to Kulim Plant, and some are offered VSS. Retain R&D in Penang
2012	Sanmina-SCI	PCB Board	800	US	Move to Wuxi, China
2013	Yahorng	Audio equipment	N.A.	Taiwanese	Move to Dongguan, China
2013	STATS ChipPAC	Leaded Wirebond Packaging & Testing IC	1,100	Singapore	Move to Qingpu, Shanghai
2015	Panasonic TV	Electrical	500	Japanese	Closed as Panasonic is exiting TV manufacturing in Malaysia
2015	JVC Kenwood	Electrical	500	Japanese	Closed due to industry shift; no demand for video recording cameras

Year	Name	Segment	No. of Empl. Aff'ted	Country of Origin	Notes
2015	Fairchild Semicon.	Semicon.	1,000	US	As part of global restructuring Fairchild disposing of old test and assembly line

Note: NL= The Netherlands, Semicon. = semiconductor, Empl. Aff'ted = employees affected'
Not all exits are due to competition with China: for JVC Kenwood, the exit is due more to a shift in the industry. The incorporation of a video-capturing function in mobile phones has drastically trimmed consumer demand for the dedicated video camera.
Source: Own elaboration based on multiple sources

Next, the type of firm entering and leaving Malaysia is reflective of the country's changing trade patterns due to competition from China. Chapter 6 discussed Malaysia's loss of exports of audiovisual products such as radios and music players in 2002-2012 while China's share of imports to the major destination markets increased for the same products. As shown in Table 8.4 above, at least four audio manufacturers left Penang in 1994-2013, consistent with the decline in audiovisual exports from Malaysia. Most audio players had left by 2004, three years after China joined the WTO in 2001.

Figure 8.9 No. of Employees in Computer Industry and Peripherals (MSIC 30002)



Source: Department of Statistics Malaysia, *Monthly Manufacturing Bulletin*, Various Issues

From the E&E industry level, I now focus on Dell Computer, which has shifted its production of desktop computers from Penang to Xiamen. Dell Computer is a North-American MNC that manufactures PCs and has a Malaysian and a Chinese plant. The Malaysian plant was opened in 1996, while the plant in Xiamen, China was opened in 1998, with a second factory added in 2006 (Chang and Meidong, 2011). Initially, there was fear that Dell would leave Malaysia when the desktop PC manufacturing was moved from Penang to Xiamen in 2001, the year coinciding with declining employment in the computer industry across Malaysia as

Figure 8.9 shows above. The lowest employment recorded is 28,318 employees in 2002, falling from 38,082 employees in 2000 and recovering with 29,228 in 2003 to peak at 63,745 in 2010, driven by investment in computer peripheral manufacturing. Most notably, in the hard disk drive industry in 2010, Western Digital invests US$1.2 billion in Malaysia (Reuters, 18 May 2010) reportedly creating 10,000 jobs.[116]

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[116] 2005-2008 saw computer peripherals expanding with higher employment as shown in

The worst fear, of Dell shutting down its Malaysian operations, has yet to materialise. Penang continues to manufacture for Dell (Dell Inc. , 2013, pp. 8.), and now supplies its most sophisticated offering, Dell servers (Goh, 2014).[117] Malaysia is also a Global Command Centre, one of the five Dell centres in the world to provide assistance and technical support to customers and spares if needed (The Star Malaysia, 2014a). Dell has two other service centres in Malaysia, located on Penang Island and Cyberjaya located in Selangor state, apart from the Bukit Minyak manufacturing plant in Penang. As Dell moves from the commoditised PC desktop market in response to a competitive global market to the marketing of services to enterprises as its key repositioning strategy, Penang remains relevant and has been given more sophisticated goods such as servers to manufacture within Dell's supply chain.

Dell's moving its PC manufacturing from Malaysia to China demonstrates the difficulty of ascertaining the 'China effect' on Malaysia as the factors driving FDI are not mutually exclusive. As mentioned earlier, Zhou and Lall (2005) econometrics study argues that without discernible data on market-seeking, efficiency-seeking or substitutable FDI it is not possible to arrive at a conclusion about this effect. [118] In Dell's case, these three factors co-exist. Dell's investment in China is market-seeking, its intention to serve the Japanese and Taiwanese markets by locating the production centre closer to the market while anticipating a boom in local Chinese demand for PCs. Charles Cheung, the managing director of Dell China, said 'Having a production base in China is necessary to sell in the Chinese mainland market' (Chang and Meidong, 2011).

Figure 8.9, consistent with entry of two additional solid state drive players (see Figure 8.7).
[117] Dell last available annual report is for 2013 as Dell as was privatised at the end of 2013.
[118] Zhou and Lall (2005) argues that production substitution can occur in efficiency seeking investment but is not likely to occur as part of resource-seeking or market-seeking investment, which, they argue, will occur anyway.

Dell is also looking at the efficiency gained from both lower labour costs after relocating desktop production to Xiamen in 2001 and logistic gains from shipping PCs from Xiamen to Taiwan and Japan. Dell custom-built desktop PCs are time sensitive products and therefore being closer to the customer cuts the order to delivery time. Cheung of Dell China added that '[m]ore importantly, there is a geographical advantage in its location between the Yangtze and Pearl River deltas. And it's very good for Dell to develop its logistic network and supply chain, as we rely mostly on the direct sales and build-to-order (business) model' (Chang and Meidong, 2011).

Finally, the fact that Dell shifted the production of its desktop PCs from Penang to Xiamen shows that production is substitutable between the two locations, making it hard to classify FDI as market-seeking or efficiency-seeking or substitutable production in a mutually-exclusive way.[119] This makes it hard to judge whether the relocation of Dell's desktop PC manufacture is truly 'production substitution'. In contrast to the E&E sector, a foreign company buying into a mine somewhere in Malaysia is clearly a resource-seeking investment.

Reverting to the sectoral-level discussion in Penang, the impact of competition from China as an FDI destination creates short-term job losses, but in the longer term, results in the upgrading of the industry and the workforce. During the slowdown in Malaysia in 2001 in the midst of E&E job losses the country keenly felt the competition from China, as a premier

[119] Some types of production can be fragmented and substituted more easily than others. For example, in the chemical and paper industry the fragmentation of the production process is less likely due to the nature of the production of chemicals and paper (ibid). However, in the electronics industry production can be fragmented with multiple components produced in different locations, and assembled in a final location.

location for assembly trade. *Business Weekly* reports that in the first three quarters of 2001 Penang lost 12,000 jobs, or 10% of its manufacturing workforce, and including highly-skilled workers such as engineers, as MNCs moved to China (Balfour, 2001). This situation prompted the CEO of Penang Skills Development Centre (PSDC) in Penang to say 'People at the grass roots don't realize how big a threat China is to us' (Balfour, 2001).

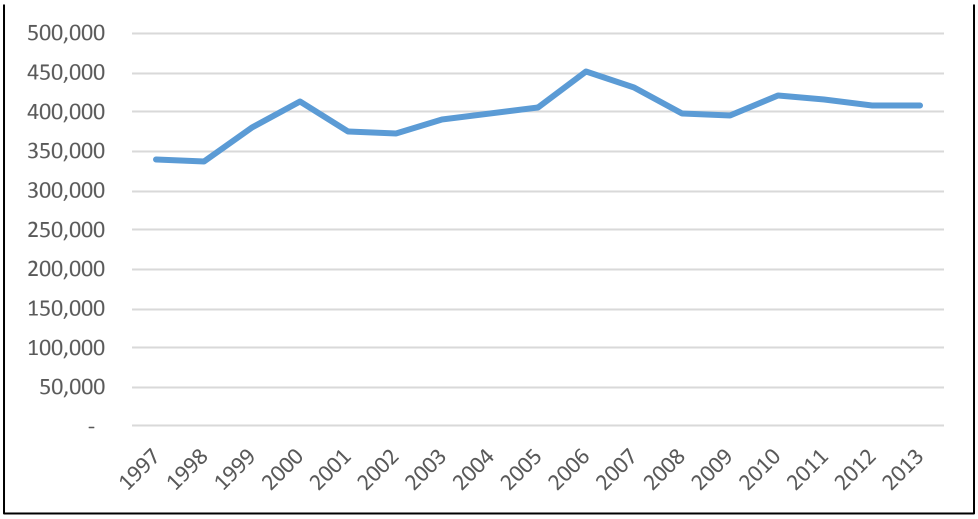
However, scholars such as Lüthje et al. (2013) and a Penang E&E veteran saw these jobs losses in 2001 as the beginning of the restructuring of E&E and the upgrading of facilities in Malaysia. With the assembly-line manufacturing leaving Penang, MNCs brought in more advanced manufacturing technology into Penang. For example, in the contract manufacturing segment a US MNC moved its low to mid-tech production processes to China and replaced its Penang plant: 'The previously dominant-assembly line is complemented by cell based manufacturing, particularly in systems integration' (Lüthje et al., 2013, pp. 119). Product-wise, Solectron 'refocused on server and networking products after 2003', including bringing the most sophisticated network routers to Penang 'following the almost complete loss of printed circuit board assembly for PCs and hard disk drives' (Lüthje et al., 2013).

8.3.2 China's diversion effects at Malaysia's national level

This section discusses the Chinese effect on Malaysia's E&E sector via the investment channel using national production data. Sjoholm (2015) study tracing the determinants of Southeast Asia FDI argues that production data is a better tool to capture the presence of FDI as it reflects the type of FDI.

As a start, overall employment figures in the E&E sector in Malaysia have increased from 339,155 in 1997 to 408,745 in 2013, as shown in Figure 8.10 below. Although the E&E employment growth rate is low at an average of 1.2% per year in 1997-2013, overall employment in E&E did not decline. This can indicate the labour market shifting across the sub-sectors, but without panel data it is not possible to track whether former employees in Penang moved out of manufacturing to join other services in the Malaysian economy.

Figure 8.10 Total Employment in E&E Sector

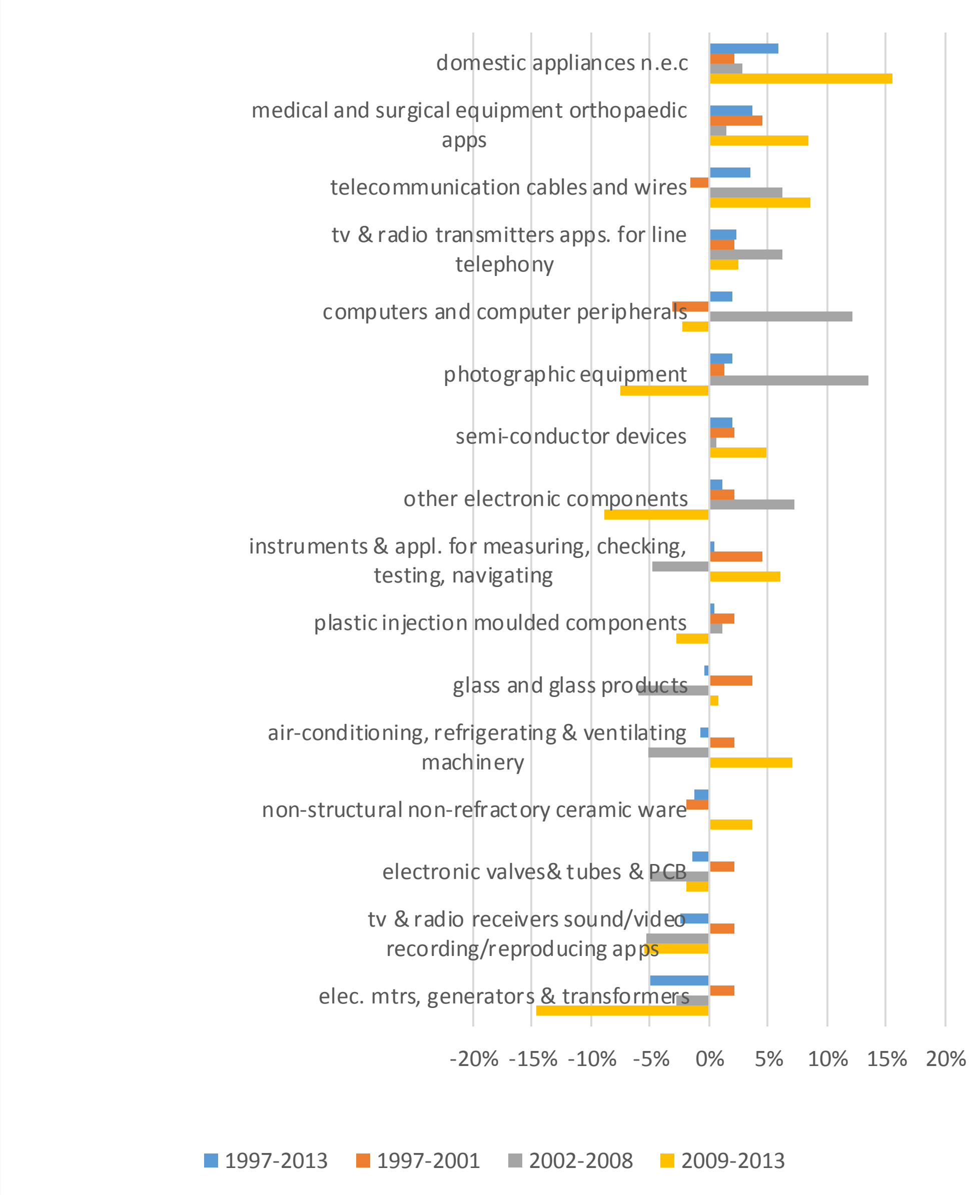


Source: Data from Monthly Manufacturing Survey, Department of Statistics Malaysia

The changes in Malaysia's labour market by E&E sub-sector are presented in Figure 8.11 below. Employment by sub-industry in 1997-2013 shows that with the exception of *domestic appliances n.e.c*. employment in finished electrical goods declines. In contrast, employment in sub-industries such as semiconductors grows. Employment in 'brown goods' such as in the TV industry, in which China competes for exports (see Chapter 6), declines, as imports from Malaysia at the destination markets decline. Employment in *TV and Radio Receivers* fell by 2.4% in 1997-2012. Similarly, consistent with the parts and components analysis in Chapter 6, employment in *electronic valves and tubes, PCB Boards* declined by -1.4% in the same period. See

Appendix 3.2 for the list of Malaysia Standard Industrial Classification (MSIC) codes.

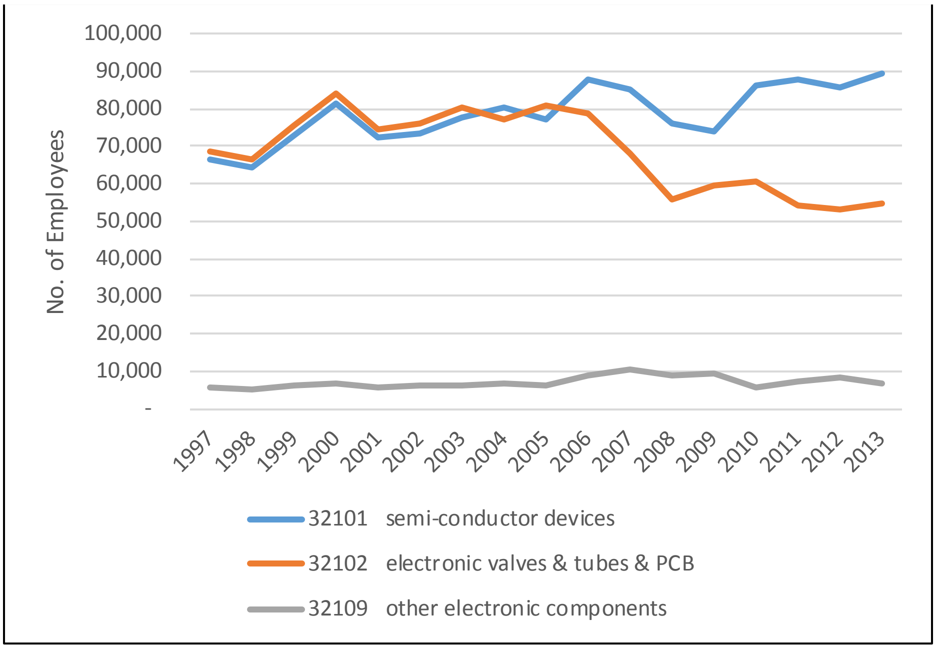
Figure 8.11 Employment in E&E sector by Sub-industries in Different Periods in Compounding Annual Growth Rate (CAGR) (%)



Note: Industry categories *other electronic and electric wires and cables; metal-forming machinery and machine tools; other special-purpose machinery n.e.c.; electricity distribution and control apparatus; batteries and accumulators; lamps & lighting equipment; other electrical equipment n.e.c.; machinery for textiles; apparel and leather production;* and *office and accounting machinery* are omitted in the above due to non-availability of data in 1997 to calculate the growth rate for the entire period of 1997-2013.

Source: Department of Statistics, Malaysia

Figure 8.12 No. of Employees by MSIC Code Semiconductor Industry



Source: Department of Statistics Malaysia, *Monthly Manufacturing Bulletin*, Various Issues

The production data above indirectly verify the upgrading of the E&E industry, for instance in the case of Solectron in Penang. Figure 8.12 shows that Malaysia is shedding labour in *Manufacture of electronic valves and tubes and printed circuit boards* (MSIC 32102) while employment has increased in the semiconductor industry (MSIC 32101). *Manufacture of electronic valves and tubes and printed circuit boards* (MSIC 32102) lost 13,524 jobs from 1997 to 2013 and there was a marked decline in PCB industry employment from 2005 (80,722 employees) to 2008 (55,858). While for 2008, the lower figure in 2008 was also a result of the global financial crisis, the decline is permanent, going beyond 2010. The decline although is in the employment aspects, reflecting the exit of PCB companies from Malaysia and in some cases, such as Solectron (later bought by Flextronics) in Penang, remaining in Malaysia but retool their factory lines by upgrading from the assembly line to more automated production (Lüthje et al., 2013).[120]

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[120] The employment data for PCB industry does fit the Inari story that 2005 was a bad year for the industry (see Section 8.4.1). Although, the Inari co-founder refers to

The data on the movement of labour in the electronics segment fit the story of upgrading and is consistent with the trade patterns discussed in Chapter 6, with Malaysia increasingly specialising in more sophisticated semiconductors and firms in the PCB segment exiting Malaysia and moving to China and Vietnam. Employment in *Manufacture of semi-conductor devices* (MSIC 32101) actually increased from 66,206 workers in 1997 to 89,480 in 2013 during the time that the PCB industry was shedding employees, and the number of employees in *Manufacture of other electronic components* (MSIC 32109), which includes electronic displays from non-LED and other electronics increased marginally from 5,376 workers in 1997 to 6,498 in 2013.

Despite the passing of the period identified as China 'diverting' investment massively from Malaysia (2000-2005) where more MNCs exiting Malaysia's manufacturing scene, China continues to have an impact on Malaysia's electronics industry. One example is the PCB fabrication plant of Sanmina-SCI, an EMS in Sarawak move to Wuxi in 2012. China short term effect resulted loss of 800 jobs in Sarawak (Lim et al., 2012). This event shows the terminal decline of PCB operations in Malaysia, as reflected in Figure 8.12 above.

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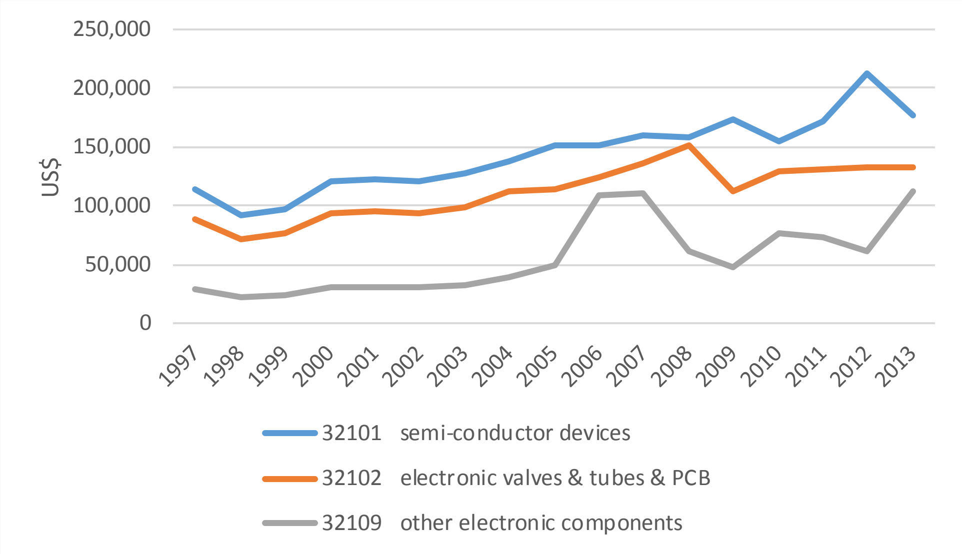
semiconductor industry in 2005 of Penang, Figure 8.12 above shows that the PCB industry is hardest hit.

Figure 8.13 Labour Productivity in the Semiconductor and Electronics Industry



Source: Monthly Manufacturing Survey, Department of Statistics

This upgrading of the value chain is further supported with Figure 8.13 above that shows labour productivity for the *Manufacture of electronic valves and tubes and printed circuit boards* (MSIC 32102) actually increase from US$114,400 in 2005, to US$151,900 in 2008, corresponding with the period of firms shedding employment in PCB factories.[121] One could argue that the increase in productivity could be due to savings from shedding labour in the sector. However, as firms exit from Malaysia to move to China for PCB manufacturing and with other factors being held constant, labour productivity is expected to decline or stay constant as less firm means less revenue or sales figure too. However, in the Malaysia's case, this did not happen, in fact the productivity increase most when labour are being shed in the PCB sector when a firm exits. Although shedding labour can have an impact on increase productivity but the steep increase especially from 2004 onwards can be reflective of the upgrading within the value chain such as in the case of Solectron in Penang.

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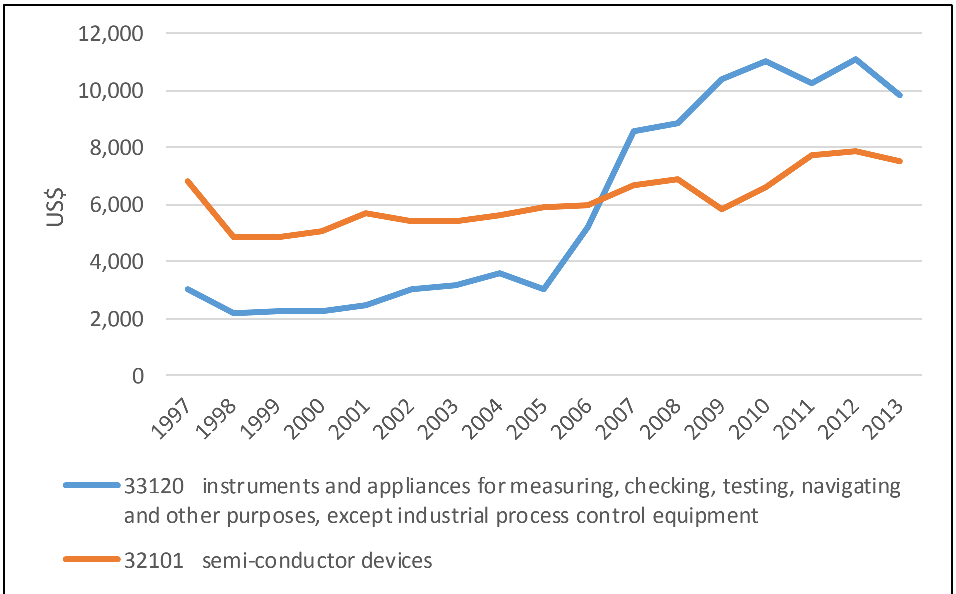
[121] Labour productivity in Malaysia = Sales Value/no. of workers, while it is a much better to use Gross Value Added method, the intermediate inputs are not available at MSIC 5 digit codes level. The weakness here is that if the industry that has high level of import content, which the E&E is one of them, there are potential issues with the labour productivity such as overestimating the level of labour productivity.

The data on annual wages per employee also show wage levels have been rising. As the wages data are affected with the cost of living (interview data), the data is deflated using the Malaysian Consumer Price Index. Next, the real annual wage per employee data are used to compare the most important sector in E&E, the semiconductor sector with one of the fastest growing sector, SEM. Specifically, I am comparing the real wages for the *Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment* (MSIC 33120) with the *semiconductor devices* (MSIC 32101) sub-sector as in Figure 8.14 below.

Figure 8.14 Comparing Real Annual Wages per employee in the Semiconductor Industry and Semiconductor Test Instruments (SEM)



Note: Wages adjusted to Real Figures using CPI provided by DOS Malaysia, 1994=100

Source: Own Calculations based Department of Statistics Malaysia

Based on annual real wages per employee analysis, it is hard to conclude whether the E&E sector has upgraded although the growth for average wage per E&E worker outpace the inflation rate. The average wage for an E&E worker (based on 24 MSIC codes) is US$3,066.8 in 1997 and grew to

US$5,909.3 in 2013 at annual pace of 4.2% against average inflation rates of 2.4%.

Although semiconductor workers are paid higher than the average sector wide E&E workers, the relatively flat growth rate in wages, it is unclear if average wage per workers captures the upgrading of the value chain within the semiconductor industry. Based on annual wages calculations, the average wage per worker is the semiconductor industry only grew on average 0.6% per annum from 1997-2013 period, which is below the inflation rate. However, the semiconductor industry (MSIC 32101) wage per worker improves from 2005 onwards, with the average wage per worker rose from US$ 5909.69 in 2005 to US$ 7517.50 in 2013 at 3.5% per annum.

Interestingly, SEM is the most dynamic sector for a wage earner rather than the semiconductor industry. From 1997-2013 period, real annual wage per worker grows at 7.6% per annum in the SEM sector actually outpace growth of wages of semiconductor at 0.6% per annum by a high margin. Although semiconductor still remains the one of the sub-sector that pays the highest (wage) among all sub-sectors, it is hardly the most dynamic sub-sector in terms of growth in wages. Around the year 2006, the average annual wage of workers found within semiconductor test equipment (MSIC 33120) surpasses the wages paid to an average worker within the semiconductor industry (MSIC 32101) as in Figure 8.14 above.

This is a significant as the definition of *Manufacture of semi-conductor devices* (MSIC 32101) includes *'diodes, transistors and similar semi-conductor devices, photosensitive semi-conductor devices including photo-voltaic cells, mounted piezo-electric crystals, electronic integrated circuits* *and micro-assemblies of moulded module, micromodule or similar types.'* (Department of Statistics of Malaysia, 2000); represents the industry that the Malaysian government has been targeting, namely LED industries, solar panel industry beginning from 2000, to counter the lower assembly line industry that is leaving Malaysia. Although MSIC codes is aggregated up to the extend it is hard to pin down the semiconductor sector progress by itself, MSIC 32101 code represents Malaysia's targeted sector of semiconductor, photovoltaic module and LED industry. The result of 32101 is that although it increases as a source of employment for the population, the annual wage per worker in the sector is relatively flat. The inclusion of the photovoltaic module in code MSIC 32101 partially explains why average wage data could not show the upgrading in the semiconductor industry.

In contrast, instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment (MSIC Code 33120) real wages per worker in Figure 8.14 is increasing while employment is increasing at the same time as shown in Table 8-5 below.

Table 8-5 Number of persons employed comparing MSIC 32101 and MSIC 33120

	no. of persons	
Year	Semiconductor (MSIC 32101)	Semiconductor test Instruments (MSIC 33120)
1997	66,206	9,562
1998	64,296	10,167
1999	72,954	9,799
2000	81,495	9,880
2001	72,238	11,412
2002	73,408	10,724
2003	77,487	9,969
2004	80,306	5,862
2005	77,161	5,194
2006	87,849	7,892
2007	84,839	7,607
2008	76,239	8,016
2009	74,143	8,189
2010	85,950	10,854
2011	87,808	8,106
2012	85,663	8,369
2013	89,480	10,342

Source: Department of Statistics Malaysia

The number of employment for *semi-conductor devices* (MSIC Code 32101) is increasing and this has an impact on real average wage growth per worker. The real wage growth from 1997-2013 for MSIC Code 32101 was only 0.6%. The increase in MSIC Code 33120 is consistent with an industry displaying its upgrading, with higher wages over a medium term (more than 5 years).[122]

[122] MSIC 32101 does include oscilloscope, spectrometer, which means some of Agilent Technologies, an MNC based in Penang wages are also in the same category as SEM sector. However, this means Agilent has always been in Penang, the increase in annual wage per employee from 2005 onwards is not likely to be caused by Agilent ramping up wages for its workers.

8.3.3 Other findings

The second main finding is that R&D managers regard China as an opportunity as the R&D can tap different areas for different skill sets, and create synergies among different locations. For example, an American MNCs operating in Penang, said that they rely on India operations to concentrate on software, Penang concentrates on the hardware design of their product, while, China R&D division help the MNC to localize their products to the Chinese market. These R&D Managers' view is valid because, supposed a product is now manufactured in China, but the design is partly contributed by Malaysian engineers based in Penang but in a trade data analysis, Penang would have 'lost out' to China based on competitive analysis.

Managers of E&E firms also observe the decision to relocate to China also includes costs competitiveness and potential sales on the location of the MNCs. Based on where cost including labour costs is competitive, then the MNC will choose to remain in current location or move to a new location. Recently, China's labour cost especially in the coastal cities has increased, this trend also has contributed to the surge of enquiries from MNCs wishing to relocate to Malaysia in E&E industry (interviewee 11). For example, Sandisk, which already has a plant in China will invest approximately RM1.2 billion (US$366.7 million) plant in Batu Kawan, Penang in 2014, with the R&D centre to be located in Singapore.[123] Sandisk is a North-American company that design and manufactures flash memory devices such as memory stick or thumb drives. (Tan, 2014a) Another example cited was the recent Intel moving its manufacturing facilities from Shanghai to Chengdu, Sichuan in China due to higher costs in Shanghai. Another one is HP, to manufacture printer heads with RM1 billion

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[123] Conversion rate US$1=RM3.2729 provided by Central Bank of Malaysia.

(US$305.5 Million) investment in Batu Kawan Penang (Tan, 2014b).[124] The managers' based in Malaysia observation further points to China's costs competitiveness advantage is disappearing with more MNCs relocating back to Penang.

Managers based in Penang who think China's is competitive qualify their statement that for now, the impact is limited given that China is still targeting the high volume low price segment, but they also pointed out that this will eventually change in the near future. The managers then pointed out that how China will impact on Malaysia will depends on how fast Malaysia can leverage on existing assets and human capital, with rapid recall of highly skilled Malaysian human resources from abroad to respond to this challenge. Based on a World Bank Report, highly educated Malaysians abroad are said to be reluctant to return to Malaysia, and majority prefer to live abroad in Singapore and Australia (Schellekens et al., 2011). This creates a massive skill gap and Penang is not able to make the leap into electronics in the way that South Koreans and Taiwanese were able to. Rasiah (2011) argues that the ethnic policy is partially slowing Malaysia upgrading by discouraging real entrepreneurs from emerging and dampening the ethnic Chinese business drive to move into high value-added activities.

For the third findings of China's impact on Malaysia's E&E sector, I travelled to visit a Taiwanese company that has left Malaysia, and moved its plant to China. The company subcontracts manufacturing of low to mid sophistication products segment such as turntables, radio, and audio mixer products, audio products for MNCs. The company has a plant in Malaysia in 1997 but shifted most of the manufacturing line to Dongguan, Guangdong

[124] Ibid.

Province in China beginning from 2003. The company subsequently terminated the manufacturing plant in Penang and delisted from the Malaysian bourse in 2013 and shifted the entire manufacturing to Dongguan facility. The R&D function of the company is kept in Taiwan. The visit confirms the worst fear that once the main manufacturing lines, though not the entire firm relocated to China, the supply base will move entirely to China. Although initially some Malaysian suppliers still retain some orders, but eventually all Malaysian suppliers for the manufacturing company are terminated. On the flip side, some Malaysian key production employees at managerial level were brought in to help setup and run the production in China for the MNC, and in the process, Malaysian managers gain regional experience. The reason for the shifting of the entire supplier base is costs competitiveness as prices offered by Chinese suppliers are much lower than Malaysian suppliers.

However, there are some factors that dampen the China diversion of investment from Malaysia. These factors include the segmentation of MNCs operations in different locations, the US legislation on dual use, and the lack of IP protection in the China market. These factors slow or indirectly mitigate the shifts or diversion of FDI from Malaysia to China.

8.3.4 Mitigating factors on the Impact from China on Malaysia

Despite some firm moving their investment from Malaysia to China, the impacts of China on Malaysia are mitigated by factors such as the segmentation of MNCs operations in different locations, the US legislation on dual use, and the lack of IP protection in the China.

Segmentation of production function by the MNCs in the E&E industry with Malaysia given higher sophistication product responsibility mitigates the impact of China on Malaysia. A North-American IC producer and a Germany semiconductor company have Penang to manufactures high margin products, while China plant production targets the lower segment of the electronics product. A German MNCs is opening a manufacturing plant (at the time of interview) for LED home lighting described as low margin and volume game in China; while LED headlamps for cars used in the automotive industry, described as high margin and cutting edge technology is currently manufactured in Penang. These MNCs allocate in different locations for different market segment rather than treating opening a new plant in China as automatically meaning 'substituting' the investment from Malaysia to China.

The US legislation of 'dual use' prohibits the building of 'state of the art production facilities for China and this constraints the transfer of technology from US to China. (Li and Yang, 2013) Dual use refers to products that can be used in civilian goods and in military hardware. The IC chip is one of the main components in missiles and drones technology. This legislation restrictions means American IC chips producers will be restrained from build their latest wafer fabrication plant in China. This US legislation indirectly helps the Malaysia FDI strategy of China+1 for the moment. China +1 strategy is a term used by E&E industry in Malaysia to persuade many of the MNC to retain the production in Penang as a hedge against risk of locating all production in one site (interviewee 8).

Moreover, managers are concerned about moving their 'state of the art' design and production to China due to IP protection issues; fearing their technology will be copied in no time, resulting in the loss of competitiveness of the firm. Consequently, some high technology firms have only sales offices in China, but R&D and production facilities are kept in Malaysia and other Southeast Asian locations. A North American flash memory manufacturer recently wrote in its annual report that IP issue including counterfeiting has a detrimental effect on its financial operations globally (Sandisk Corporation, 2014).

Arising from the IP protection issue, an investment promotion agency in Malaysia reveals that foreign investors are looking to re-locate plants back from China to Malaysia (interview 11). Some other reasons cited are rising costs in coastal cities of China and other administrative difficulties in China.

8.3.5 Interactions between Trade and Investment Channel of 'China effect' on Malaysia

Interestingly, export competition between indigenous Chinese companies with the MNCs based in Malaysia makes foreign MNCs less likely to re-invest or expand their business in Malaysia as their profit margin is hit. Deducing from this and taking the solar module industry in Malaysia as an example; Bosch, a German company was cited as cancelling their investment in RM2.2 billion (US$ 712.3 million) plant in Batu Kawan, Penang (Tan, 2012), due to falling international prices of solar module (Mok, 25 March 2013).[125] The falling prices are due to the competition from China in solar panel module. (Abhishek Shah, 2011). This Bosch example shows trade effect from China can affect Malaysia's FDI prospects and in this case, constraining FDI from traditional sources.

On the other hand, effects from China in the trade channel can also boost Malaysia's FDI prospects, and in this case, it happens to be solar module

[125] Based on conversion rate US$1= RM3.0888.

industry as well. South Korean company Hanwha SolarOne, which controls Q-Cell of Germany recently announced *'it would stop making solar cells in Germany and ship its factory to Malaysia to cut costs'* and to create size to compete with Chinese giants in solar module such as Yingli Solar (Martinez and Landberg, 22 January 2015). Although by chance, Malaysia lost and regains FDI opportunities by the China effect in the solar module case, it shows that trade and investment are not mutually exclusive channels, but impact from China can interact between the channels as well.

8.3.6 Conclusion for Section 8.3

Based on electronics firms' movements into and out of Penang and job data, China's rise has resulted in job losses and the exit of firms manufacturing E&E products of lower sophistication such as PCB operations. However, this has also spurred the upgrading of Malaysian E&E value chain, with MNCs replacing lower technology assembly operations with higher-value more sophisticated manufacturing techniques for higher specification goods.

Data on annual wages per employee shows that the SEM segment has paid its workers more than the much-prized semiconductor (MSIC 32101) segment since 2006, further indicating that Malaysia's SEM is upgrading.

From R&D managers' point of view, China is a complementary force for Malaysia as each country can tap into different research strengths in different locations. Finally, a field visit to a company that has shifted its production line from Malaysia to China revealed that when the supply chain moved to China Malaysian suppliers were cut out of the supply chain.

8.4 Malaysia's response to competition from China

A Malaysian public sector official observed that China's effect on Malaysia will depend on how Malaysia reacts to China. A contrast between the reactions of the states of Penang and Sarawak brings out this point. Penang reacted with more upgrading on the part of MNCs based in Penang and the formation of SEM firms, while Sarawak responded by going upstream: after losing 800 jobs from Sanmina-SCI's move to Wuxi China in 2012, Sarawak received investment from Tokuyama of Japan and Comtec of China. [126] In terms of position in the value chain Sanmina-SCI, a global EMS, is a downstream player, while Tokuyama is an upstream player that manufactures silicone ingots in Sarawak and ships them for further processing in Japan; Comtec of China is also a silicon ingot and wafer producer.

The rest of the section discusses Malaysia's response to China's rise in the E&E value chain in both the private (firm) and the public sector. This section addresses the research question: How do Malaysia's firms and public sector respond to China?

This section addresses the research question of Malaysia's response to China both at firm level and at public sector level to the rise of China in FDI attraction. The Malaysian public sector measures discussed here aim to attract more investment and increasing exports given the close link between trade and investment in Malaysia's E&E sector.

[126] Rietema and Velden, 2013 also concludes that between 1994 and 2013, Penang has upgraded its E&E industry.

8.4.1 Firms' Response

Malaysian firms are upgrading to remain relevant in the E&E value chain. This section focuses on MNCs operating in Malaysia and local firms, as Malaysian firms that have gone abroad to invest in China have been covered earlier in this chapter.

Firms' responses include upgrading, expanding horizontally rather vertically in the industry, and seeking partnerships. An example of vertical expansion in the IC industry is firms making smaller, thinner and faster ICs, while firms that expand horizontally try to match current ICs with new capability in other sectors such as the biological sector, namely in the creation of bio-chips that can be embedded in plants for better crop yield.

Malaysia's E&E firms' responses to China's rise include products upgrading and processes upgrading. Malaysia is also starts to perform functional and intersectoral upgrading, but do not include chain upgrading.[127] Product upgrading can be seen in the move of the manufacture of lower-margin products to China and Vietnam, with Penang concentrating on higher-margin products as part of the segmentation of activities by MNCs operating in region. Process upgrading is the strength of MNCs based in Malaysia, as Malaysian plants constantly find ways to minimise the cost of producing electronic products. MNCs based in Malaysia carry out Research and Development (R&D), a form of functional upgrading, along the value chain. Interview data shows that R&D activity is also picking up among locally-owned entities in Penang.

[127] Some scholars call this intersectoral upgrading, in which firms such as Pentamaster and TT Vision use existing knowledge to enter other related sectors but chain upgrading actually refers to discovery of a breakthrough that upgrades of the entire value chain, like discovery of fibre-optics revolutionised the way electronics data is transmitted.

Penang-based firms are developing R&D capabilities, a functional upgrading reflecting a shift from previous manufacturing activity to research and design along the semiconductor value chain. Penang is one of Altera's main R&D centres outside the US, while the next generation of another North American MNC microprocessor is also co-designed in Penang and will pass through technology development in Penang before going into production (interviewee 1). In 2006, Intel announced a US$40 million R&D centre in Kulim, Kedah, to design 'microprocessors, chipsets, motherboards, server boards and custom microchips for use in Intel's product lines' (Hopfner, 2016) adding 900 designers to the 3,000 workforce in Kulim plant.

On Altera again, one of the two major companies competing in the field-programmable gate array (FGPA)[128] market has an R&D centre in Penang. Altera has no factories in Penang but coordinates global demand in Asia, Altera Penang gains a functional upgrading with functions resembling a Regional Headquarters for the East Asia region within the organisation. Although Altera Penang does a lot of tweaking of existing products, it is beginning to pick up some IC design activity for the design of the core of the ICs (interviewee 7) referring to the logic circuits units of the IC (die of the IC chip before it is packaged).

Local firms are also upgrading functionally. For example Globetronics, an EMS that serves MNCs Penang's semiconductor industry, is upgrading. It is now co-developing products with customers and expanding horizontally by acquiring capabilities in and synergising with other areas such as medical devices, using electronic sensors as a basis (BFM 89.9 The Business Station Malaysia, 2014). This horizontal strategy is also the way forward for a

[128] In FGPA the IC is programmable, and typically commands a higher price than common microprocessors produced by Intel.

semiconductor front-end player in Malaysia going into fabricating niche chips such as bio-chips that can be used in agricultural cultivation. This horizontal strategy can also be read as inter-sectoral upgrading (Humphrey and Schmitz, 2004).

The level of R&D performed by local firms in Penang, although commendable, is still far from the type of R&D performed by the MNCs (interviewee 8). Despite this, Malaysian companies such as Penang Vision, Aemulus and Ceedtech are the few bright sparks in Penang. Some MNCs interviewed in Penang said that some local companies do perform high-technology R&D, but the details are confidential. Finally, to put the level of R&D at Penang firms such as Penang Vision, Aemulus and Ceedtech into perspective, it can be described as level 5 (an early stage of R&D) out of 6 based on Rasiah (2010) taxonomy of R&D (see Appendix 8.3). These firms have not reached a level of research that can revolutionise the whole industry.

A case study of the Inari-Avago partnership in Penang demonstrates the response of Malaysian firms to Chinese competition.[129] Some FDI literature notes that the weakness of FDI as a model for development is that MNCs draw talent away from indigenous firms, as the former normally pay higher wages. With China drawing FDI away from Malaysia, the competition for talent between indigenous firms and MNCs based in Penang is less intense than before. In fact Inari has hired some ex-Avago engineers as Avago seeks to close its back-end manufacturing operations in Malaysia. An interview revealed that the combination of the down cycle in the semiconductor industry in 2006 and E&E firms relocating to China helped

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[129] Inari calls it a strategic partnership, with Avago initially holding 13% of the stake in of Inari during the start-up period but later the stake is was sold off (BERNAMA, 2011).

Inari to secure plant buildings at lower cost during its critical start-up period (Interviewee 9).

The Inari case is an important lesson for a developing country upgrading in the E&E GVC, including product upgrading and process upgrading. This upgrading is reflective of broader efforts by Malaysian firms, including Penang-based SEM players. There is a need for more Malaysian firms to move towards functional upgrading, and possibly chain upgrading, which will result in radical changes that will see the country earning from licensing intellectual property with pools of highly skilled workers. Inari's partners such as Avago have already attained this stage. Inari is also starting to invest in R&D in the back end of the semiconductor business, but details were not disclosed in the interviews.

As an illustration of how China attracted E&E firms away from Penang created the opportunity for new local start-ups, I elaborate on Inari's beginnings as a start-up company. In 2005, Dr. Tan, one of the co-founders of Inari Bhd, returned to Penang from Taiwan and China after spending years in the electronics industry abroad, to start manufacturing set-top boxes in Penang. Coincidentally, Avago Technologies, with a presence in Penang, a NASDAQ-listed company that designs and manufactures RF chips used in mobile telecommunications and fibre optics, was looking at outsourcing the back-end manufacturing of its RF chips. Tan and PG Ho, both having the financial resources, met up with Edward Mai and John Tan of Macronian, which had the system-in-package capability) that Avago needed to package its RF chips.[130] These four co-founders decided to jointly bid for Avago's outsourcing of its manufacturing operation as the new firm Inari Technology (Ali, 2011). Dr. Tan remarked that 'In 2005 and

[130] A system-in-package is contains more than one ICs packaged within one housing forming a system (PC Mag (b), 2015).

2006, Penang semiconductor players were rushing to China. About 30% to 35% of the factories on [Penang] and Prai had closed down'(Ali, 2011). [131] Crucially, this gave Inari a head start because it was easy to source a cheap factory and the required machinery building in Bayan Lepas, Penang (interviewee 9). Against this backdrop, Inari began in 2006 as an EMS performing back-end manufacturing for Avago.

Beyond the Inari-Avago partnership, Inari was supported by a Penang Network, which was crucial during the start-up phase. 'Penang Network' is a loose term describing the informal networking among Penang's E&E players. When Inari first started, many SEM vendors supported it to give it a head start. In short, to 'get machines, get suppliers and get clients all within Penang ... Penang has the eco-system to do this'.[132] There was goodwill was because the co-founders of Inari are Penang-based people who had been known in the local E&E community for many years. Had Inari started elsewhere it might not have been able to tap into such a network. The Penang Network exemplifies how spatial embeddedness remains a

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[131] There is no central database on firms leaving Penang, but using data from newspaper reports and referring to Figure 8.12 in p. 338, the PCB sector marks the start of the decline in the number of employees in 2005. Although this section predominantly has discussed China's effect on Penang State E&E industry via investment diversion, Table 8.4 show examples of major firms that have exited Malaysia at national level to further illustrate the types firms exiting from Malaysia. The majority of the firms listed in Table 8.4 are based in Penang prior to the exiting, except for JVC, Sanmina-SCI, STATs-ChipPAC and Panasonic TV.

Table 8.4 in p. 328 shows that even firms that have not formally exited Penang can restructure by offering a voluntary separation scheme (VSS), which is basically another form of layoffs. Prai Industrial Area: the mainland part of Penang State

[132] Field interviews.

relevant concept, and in this case it helped Inari to succeed and claws back some of the semiconductor businesses that had gone to China.

Another point related to China is that Malaysia has specialised more in components away from the final assembly of products, as discussed in the trade chapter. This coincides with Inari's preparation to go into the back end of the semiconductor business. Interviews revealed that Macronian staff that later co-founded Inari had specialised technical knowledge of flip-chip technology in the assembly of semiconductors, and this was a key criterion in winning the job from Avago, and with the trade structure geared towards components it prepared Malaysia's workforce to take the opportunity when it arises. [133] Inari was formed with the technical knowledge of people from Macronian and the financial backing of Dr. Tan and MR. PG Ho. [134]

Inari is a success story and the company was selected as one of Asia's best for *Forbes Magazine*'s (Forbes Magazine, 2015) Under a Billion List. Its growth has been exponential, thanks to the strategic partnership with Avago Technologies and supported by the Penang Network. Inari has grown to the extent that it can acquire local and overseas companies, broadening its portfolio to include optoelectronics, electronics test and measurement machines. In 2012, Inari acquired Amertron Kunshan for US$32 million in order to enter the optoelectronics and fibre-optics segment of the global electronics manufacturing service market. (Inari-Amertron Bhd., 2013, pp. 10.) Inari's competitors today are companies

[133] Flip-chip packages have the silicon die face down and connected to the packaging by ball joints melted and under-filled with epoxy, as opposed to the usual lead soldered package that connects the die to the lead frames of the packaging, which are typically face up (PC Mag(a), 2015).

[134] Macronian is a company name based in Penang.

such as ASE from Korea, and Ambit, which is related to Foxconn. Inari's journey is summed up in Box 8.1:

Box 8.1 Inari-Amertron Bhd Time Line

Year	Events
2006	Inari Berhad founded Contract Manufacturing with Avago Technologies
2009	Inari opens its 3rd plant in Penang, increasing floor space to 100,000 sq. ft.
2011	Inari listed on ACE Market in Bursa Malaysia (ACE Market is for smaller size companies). IPO was oversubscribed by up to 10 times.
2012	Inari acquired Amertron Kunshan of China, to enter fibre-optics and optoelectronics market at US$32 Million. Amertron serves to provide LED display for washing machines of American companies such as Whirpool. Inari acquired Ceedtech at approximately US$1.30 million (RM4 million). Ceedtech has served MNCs such as Agilent in Penang for test and measurement instruments market.
2013	Change of name to Inari-Amertron
2014	Inari-Amertron transfer to main bourse of Bursa Malaysia
2015	Revenue now hits approx. US$62.2 Million (RM228.3 Million)

Source: Inari-Amertron Bhd. (2015)

While collaboration and the Penang Network helped to make Inari successful, factors were identified during field interviews. From Avago's point of view these include cost considerations. Avago chose Inari to be one of its suppliers due to its location. From experience, physical proximity reduces the cost of resolving production problems, especially for complex products; it involves sending engineers from the principal holder of the technology to resolve technical issues. Therefore it is economical in terms of both time and cost to have suppliers located close to the technology partner. Secondly, Avago's top management correctly predicted that China's coastal area cost of production would be more expensive as a location than Penang in a matter of a few years. Therefore using Penang as a base was a natural choice. In other words, Inari's success is due to a mixture of factors and not to collaboration alone, although this has been pivotal.

Inari is an exception in Malaysia, as pointed out by a veteran of Penang's E&E industry. (Interviewee 8) There is no incentive for other MNCs to create this kind of strategic partnership due to the competitive operating environment. However, the Inari case serves to illustrate Penang E&E players' response to China's rise by increasing collaboration both among the individual cofounders of Inari and at firm level (Inari-Avago), demonstrating that Malaysia can be a sizeable player rather than stuck in second-tier SME mode in the E&E value chain. Malaysia needs more success stories such as Inari to neutralize the negative effects of competition from China for FDI.

Based on the Inari-Avago case study, China's diversion of FDI created a window of opportunity for start-ups such as Inari because buildings and other inputs became cheaper in Penang when many industrialists left in 2005, making start-up costs cheaper and giving Inari a head start. Inari's case also fits well with the view of restructuring in the E&E industry with more advanced manufacturing. In other words, upgrading involved transitional costs such as temporary job losses in Penang, but some players in Penang responded by accelerating their upgrading in partnership with an MNC. MNCs in general upgraded products and processes while picking up R&D activity in response to China's rise.

8.4.2 Public Sector Response

Some interview respondents recommended that Malaysia should focus on its internal science and innovation administrative setup and facilities, and its industrial policy on the development of its E&E industry rather than looking outwards such as to competition from China, and this brings me to the public sector's response. This section lists programmes for upgrading the Malaysian E&E value chain. The programme generally seeks to upgrade Malaysia's E&E, with China a major factor in this. The Performance Management Delivery Unit (PEMANDU), under the Prime Minister's Department of Malaysia, recognized E&E as a priority sector of Malaysia's economy for development and at the same time identified 'increasing competition from China and other Asian sites' as a case for change in Malaysia (PEMANDU, 2012, slide no. 2.).

This section discusses the main programmes of MIDA, CREST and TalentCorp, as revealed in field interviews. MIDA has restructured itself from the Malaysia Industrial Development Authority to the Malaysia Investment Development Authority to include investment in the service industry investment. Beyond the name change, MIDA also launched a RM1 billion (US$324 million) Domestic Strategic Industry Fund in 2012 to 'accelerate the participation of Malaysian-owned companies in the global supply chain, namely, high value-added, high-technology, knowledge-intensive and innovation-based industries' (The Star Malaysia, 2014b).[135] This strategic fund covers the electronics sector among other high technology industries such as aerospace, and provides 1:1 grants for R&D and training for Malaysians. Inari Bhd also received R&D grants and training grants from this MIDA programme in 2014.

[135] Figure converted using foreign exchange rate in 2012, 1US$=RM3.0888.

Targeting the E&E industry specifically, Collaborative Research in Engineering, Science & Technology (CREST) was launched in 2012 to bring about more R&D in the field of electronic engineering among E&E players in Malaysia. Based in Penang, CREST brings together academia, the industry and the government to help Malaysia move from volume-based towards knowledge-based advanced manufacturing in the E&E industry. The goal is to have firms earning from new inventions and patents, and a talent pool able to perform high-value R&D.

CREST's three major objectives are increasing R&D, talent management, and industry engagement. It provides grants to individuals to perform R&D in line with industrial needs and to create a platform for collaborative research among E&E players in Penang, something that has been missing in Penang despite many years of E&E industry experience. In terms of talent management, CREST is working in partnership with TalentCorp to bridge the gap between universities and industry needs by providing training in line with industrial requirements. Finally, to encourage industry engagement CREST brings the E&E industry in Penang together in workshops, activities and design solutions that can be commercialised. For this, CREST provides office space in Penang for industry employees to converge. CREST differs from previous Malaysian government approaches as this is industry-led research with most members from Penang based MNCs (MIDA Malaysia, 2014). In 2004, CREST introduced grants targeted at optoelectronics industries, the Internet of Things (IoT) and IC design, and set up strategic collaboration on LED research between a Malaysian educational institution and the University of California Santa Barbara. (MIDA Malaysia, 2014)

TalentCorp is a Malaysian government unit formed to attract foreigners and Malaysians abroad back to Malaysia to help with the upgrading of the

Malaysian economy. TalentCorp's mandate goes beyond E&E industry, but since E&E is a major industry in Penang, TalentCorp programmes naturally have included development of human capital for the E&E industry. At national level, TalentCorp has Returning Expert Programme (REP) that extends income tax concessions and tax breaks for car purchase in Malaysia for returning Malaysians that qualifies.

One of the major constraints in Penang is the shortage of highly skilled R&D engineers in the E&E sector such as IC, LED, and SEM subsectors. (interviewee 10). To address this FASTRACK, which is essentially an up-skilling programme launched by TalentCorp which places engineering graduates with MNCs for training to ensure that the talent pipeline is industry-ready. FASTRACK's E&E training partner is the PSDC. This differs from the previous approach in which graduates were trained before being placed, a strategy that led to mismatched skills between the training and the industry need. By placing the best graduates in E&E firms first, the skills that the companies impart are aligned with their needs. Since its launch in 2011 about 364 engineers have been through the FASTRACK programme with the aim of performing R&D for E&E firms in Penang once absorbed into the companies after finishing the programme (TalentCorp Malaysia, 2013).

The Graduate Employability Management (GEM) programme targets students who have been out of work for more than six months after graduation. TalentCorp, local universities and private start-up firms such as Penang's Dreamcatcher provide the technical training for E&E-related technical courses. Based on Rasiah's argument that ethnic policies in Malaysia dissuade highly-skilled Malaysians from returning abroad to help upgrade the industry (Rasiah, 2011), TalentCorp would perhaps have more success by training Malaysians still in Malaysia, assuming that they do leave to seek jobs in neighbouring Singapore after training.

Although not a formal strategy, the China + 1 strategy is used to market Malaysia as a location to MNCs as a form of risk management. The China +1 strategy is used to persuade investors to co-locate production facilities in Malaysia to reduce the risk of locating all their production facilities in one place. This strategy is aided by the fact that intellectual property is less secure in China due to intense copying, helping to market Malaysia as a safer location for investors.

Toh (2013) explains the weakness of the current public sector response as public sector institutions being too centralized to respond effectively to support innovation within the industry; the public sector lacking the expertise to make strategic decisions to move the industry; MNCs in Malaysia not using public research institutes in Malaysia; and interlinkages between firms in Malaysia generally being weak. The Malaysian government, aware of these weaknesses, set up the Domestic Strategic Investment Fund, CREST, and TalentCorp to improve the current innovation system.

8.5 Conclusion

There are three aspects to China's impact on Malaysia in the investment channel: the 'China effect' created short-term labour market losses; spurred Malaysia to upgrade its E&E value chain in the long term, and, as demonstrated by the Inari-Avago case, diverted FDI from Malaysia, creating an opportunity for sizeable Malaysian technology start-ups.

Malaysia is only getting receiving minimal FDI inflow from China in its E&E industry relative to its traditional investor countries. Moreover, China is investing in the E&E upstream and seeks efficiency. Based on the GVC framework this upstream investment hardly stimulates upgrading in the E&E industry, although China is still at an early stage of investing abroad. At this point Chinese investment in Malaysia is minimal, and therefore China does not 'compensate' Malaysia for its losses in the finished goods sector with more FDI inflows from China.

At the total investment level, Malaysian firms invest more in China than it receives in return. For Malaysian E&E sector firms that have invested in China the impact is generally positive. Malaysian EMS firms capitalised on low labour costs in China in the early stages to build up volume, and one Malaysian firm is a global EMS player today as a result. However, China does not suit all Malaysian firms as an FDI location and some have left China due to rising labour costs in coastal areas. A new form of complementarity has emerged, with SEM players in Malaysia benefiting from additional demand from China as E&E firms in China automate in response to rising labour costs.

The answer to the question of whether China has diverted investment away from Malaysia is not straightforward. Malaysia has been affected by the rise of China nevertheless, with short-term job losses in the domestic labour market, but overall Malaysia is upgrading, as shown by comparing the entry and exit of new firms. The entry of new firms, especially in the SEM segment, when MNCs exit Penang or shift their production line to China, signals the long awaited arrival of sizeable technology-based Malaysian firms. Secondly, R&D managers see China as a complementary force, as MNCs draw strength from multiple locations for designing new products. Finally, when a company shifts its production line from Malaysia to China the entire supply chain shifts with it, although this point cannot be generalized across the whole E&E industry.

Malaysia has responded to the Chinese challenge by upgrading its E&E value chains for both product and process upgrading. MNCs based in Malaysia are also increasingly performing R&D, signalling a step up into functional upgrading. Local Malaysian firms are also upgrading, some starting in collaboration with MNCs, such as in the case of Inari-Avago.

The public sector supports upgrading in the value chain by setting up CREST in Penang to promote collaborative research among the E&E players there. In addition, MIDA has set up the strategic industry fund to help local firms grow into sizeable players and to promote R&D. Finally, TalentCorp is tasked with increasing and upgrading the E&E industry's talent pool in Malaysia. However, Malaysia's track record for public intervention via such projects as MIMOS and the MSC project in Cyberjaya in the 1990s and 2000s has not lifted the country into the international league or created technology heavyweights with household international brand names. Given the challenge from China, the Malaysian government exhibited signs of changing strategy in 2012 by giving R&D incentives directly to local private firms, which has been far more effective with companies such as Inari and others in SEM equipment, which have been growing more steadily as a result.

9.0 Conclusions

The re-emergence of China has created both challenges and opportunities for developing countries such as Malaysia.[136] This research investigates the impact of China's rise on Malaysia's E&E sector through trade and investment channels, following the Asian Drivers framework. The study also examines China's impact on the backward linkages of the IC industry in the semiconductor test machines segment.

This chapter concludes the findings from this research, starting with the empirical findings and how these inform the theoretical framework and impact on policy, followed by recommendations for future research and closing remarks.

9.1 Empirical Findings

The bilateral trade figures reveal that Malaysia's export structure is now relatively more integrated with imports from China than with any of its other traditional main partners trading in E&E products. While Malaysia is benefiting from a higher volume of exports of semiconductors and parts and components, it also faces competition from China for electrical products and other final goods. The Malaysia-China bilateral trade balance, disaggregated by type of goods (in Broad Economic Categories), shows that China is no longer just a centre for assembly trade as it is increasingly capable of producing parts and components. Malaysia is importing these parts and components, especially those of lower sophistication. Malaysia is also experiencing higher import penetration of household electrical goods

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[136] China is a significant player in terms of manufacturing for the World GDP in sixteen century (IDS, 2006). China's opening its door to economic reform in 1979 marks the beginning of China's re-emergence on the world stage.

compared to a decade ago. This signifies the entry of big MNCs from China into the Malaysian household electrical goods market.

Although Malaysia has a trade deficit in parts and components in its trade with China, this is not necessarily a bad thing as it uses these parts and components as inputs into its final assembly and exports the finished goods to Middle Eastern markets, as demonstrated in the example of Colour TVs products in Chapter 6.

Based on a competitive analysis of trade at the destination markets for 1992-2002 and 2002-2012, E&E imports from China compete with Malaysia's exports to the US and Japan, but remain in a situation of mutual expansion with imports from Malaysia in EU markets in 2002-2012. In terms of sophistication, exports from Malaysia have been upgraded. There is competition for the most sophisticated products imported by the US. For products in the second quartile of sophistication (see Table 6.5 in p.173 and Table 6.12 in p.190), the US and Japan imports from China compete with those imports from Malaysia. This means that even exports of Malaysia's prized specialisations, such as IC chips, which fall under the second quartile of sophistication, are competing with Chinese IC chips. However, this threat is tempered by the rise in Malaysia's exports of IC chips to China.

The analysis of trade by type of goods finds that Malaysia has almost withdrawn from the US and EU markets for final goods such as durables as imports from Malaysia at destination market falls significantly by 2012. The Japan imports more durables from Malaysia than the two other destinations in 2012 consonant with the presence of Japanese FDI in Malaysia. During 2002-2012, Malaysia's export structure has largely switched to parts and components and faces competition from China for products at the first and third levels of sophistication in the destination markets.

Taking the case of audiovisual goods at destination markets, while the China is competitive and Malaysia has withdrawn from the US market the net effect is that Malaysia has diverted its exports of TV products to the Middle East. Secondly, Malaysia imports TV parts and components from China to assemble into final goods. Therefore, not all China's competitive forces are not entirely negative.

China does not make up for its diversion of investment from Malaysia's traditional sources of FDI in the E&E sector or for its loss of exports in the US and Japan market. However, it provides a platform for Malaysian companies to invest in China, although this is mainly confined to the electronic manufacturing services (EMS) segment. On the issue of the FDI diverted from Malaysia to China, this research has focused on the impact of firms leaving Malaysia, and the entry of new firms and the resulting short-term job losses. Finally, China has spurred Malaysia's efforts to upgrade its private E&E firms, aided by public sector programmes, including its backward linkage industry, the SEM segment.

9.2 Theoretical Impacts

Going back to theoretical frameworks, the findings of this research can inform studies based on the Asian Drivers. Altenburg et al. (2006) speculates that China's rise will pose entry obstacles to developing countries entering the technology based exports market given China's formidably low prices and exports of highly innovative products. However, this research on the high-technology E&E industry of a developing country such as Malaysia, collating findings for the E&E backward linkages industry, has found that contrary to Altenburg et al. (2006), China has helped Malaysia – although unintentionally, by increasing the minimum wage in its coastal industrial areas – to upgrade its E&E industry to meet the demand for automation machines for the semiconductor industry.

China competes with Malaysia's E&E exports, but it also spurs Malaysia to upgrade its E&E industry. This answers Ernst (2004) critical question whether China is a blessing in disguise for Malaysia. The mainly econometric-based studies, such as Athukorala (2009), which force the discourse into a binary yes or no, argue that China's role is mainly complementary as it absorbs Malaysia's parts and components for final assembly and exports to the US, EU and Japan (ibid). While this is true to a certain extent, especially for ICs, a competitiveness analysis disaggregated by sophistication level has shown that China competes with Malaysia's E&E exports in the first and third most sophisticated E&E export segments. At the destination markets China competes with Malaysia's prized specialization in the production of ICs, the main item it exports under parts and components.

Malaysia has upgraded its E&E value chain through products and process upgrading in response to China's challenges. Other than offering more sophisticated E&E exports, it has also included R&D and functions as the regional headquarters of some of the major MNCs operating in Malaysia.

There is some intersectoral upgrading in the backward linkages of SEM, with new generations of entrepreneurs, particularly based in Penang, who have worked for MNCs in Penang and have used the knowledge gained there to create spin-off companies designing semiconductor inspection machines. From there, some SEM players have also branched out into other sectors to design automation solution and machines for manufacture lines for other industry such as rubber glove inspection machines and medical devices.

One of the central issues discussed within the GVC/GPN theoretical framework is that trust matters more than spatial proximity among the members of the value chain, given the increasing geographical dispersion of production arrangements aided by advances in telecommunications (Pietrobelli and Rabellotti, 2012). However in the case of Penang's semiconductor clusters spatial proximity is a core consideration which in turn affects costs and trust (being located together increases trust and networking amongst the players).

9.3 Policy Impacts

Kaplinsky and Morris (2009) argue that in the textile industry the removal of preferential treatment for Sub-Saharan Africa (SSA) countries has had a deleterious effect on their exports due to direct competition from China and Vietnam. This gives rise to the question of whether a level playing field is good for the low-technology industries such as textiles in developing countries which have long been considered a stepping stone to broader industrialization of the economy. However, in this research based on relatively high technology and a mid-technology country such as Malaysia, the competition has had an upgrading effect of the industry. Chapter 6 discussed how Malaysia faces the most competition for the US market from Chinese E&E exports; and Malaysia's exports face the greatest competition in the most sophisticated segment. The competition has led Malaysia to offer more sophisticated exports. This is something for international development agencies to take into consideration when framing policy on using trade as a tool for development for countries with a medium level of technology.

Moving from international to national policy, Malaysia should aggressively pursue the development of its SEM segment, which is being upgraded and, most importantly, it includes the Malaysian-owned firms. This is the goal of the Malaysian government in its Industrial Master Plan III (2006-2020) to reduce foreign dependence in its industrial development (Ministry of International Trade and Industry Malaysia, 2006). More importantly, the SEM segment avoids competing head-to-head with China, which is aggressively pursuing the development of its semiconductor industry and exports.

Malaysia's investment policymakers should note that current Chinese investment in Malaysia is not going into segments with the potential to generate positive spillovers, with the exception of Huawei of China's training centre (although this does not come under E&E). Therefore some of incentives should be packaged to attract Chinese investment, especially involving joint research into or design of IC chips, as China now has a sizeable IC sector in its semi-conductor industry.

Some of Malaysia's key structural issues remain unresolved and potentially limit Malaysia's upgrading capability, including its lack of a distinguished university department of physics and chemistry which would give Malaysia an edge in producing scientists to support upgrading and perform research at a more fundamental level. Although unrelated at first sight, some surprising factors that frequently came up in the interviews included the deteriorating standard of English amongst Malaysian workers, the shortage of highly-skilled engineers capable of performing R&D, and the questionable quality of education and training standards overall.

9.4 Recommendations for Future Research

This research has aimed to deepen understanding of the effect of China's rise on Malaysia's E&E sector in the trade and investment channel. Future research to further enhance understanding and improve policy recommendations should cover the following:

- Cultural factors when China's MNCs decide to invest. This was in the back of the researcher's mind: when Chinese investors consider an investment do cultural factors such as language and ethnicity affect their decisions? This research could inform our understanding of how network production spreads from China to potential sites in Southeast Asia.

- Methodologically, future research could look into the impact of non-disclosure agreements (NDA) on E&E industry research compared to another industry that is not tied by such an agreement. Comparing the responses from interviewees from industry bound by NDA with another unbounded by NDA to similar questions, could reveal biases in respondents' responses to questions, the type of biases introduced where they occur.

- A comparative study of China's impact on another ASEAN country such as Thailand would be interesting, especially in the automotive sector, as Thailand is the hub of the automotive industry for many MNCs in the ASEAN region.

- Research could focus on the movement of specialised Malaysian labour following MNCs relocating from Malaysia to China to see whether this helps them to upgrade their skills and whether this labour force eventually returns to contribute to Malaysia's move up the value chain.

- Research could investigate trade friction between Malaysia and China; while this has mainly eluded the E&E sector it does not mean that other sectors, such as the steel industry, do not experience it.

9.5 Closing Remarks

This study fills a gap in the literature, where the findings of research involving simulation models and econometric studies are largely based on highly aggregated data. Based on the Asian Drivers theoretical framework and competitiveness analysis, this study finds that China is competing with Malaysia's E&E exports in the trade channel in the major destination markets such as the US and Japan. However, China mitigates this competitive threat with a greater volume of Malaysian exports of parts and components into China. Although China does not compensate Malaysia for diverting FDI from Malaysia's traditional sources this diversion has aided Malaysia's efforts to upgrade its E&E industry in response to the challenge that China poses.

Going forward, Malaysia can potentially leverage China's ambitious assault in the global semiconductor market by focusing on the SEM sector, which supports China's demand for the automation of semiconductor production and inspection. This however depends on how Malaysia addresses its internal structural issues in the industry, and factors outside the industry such as education and training standards. With the price of oil below US$40 per barrel at the point of writing, Malaysia appears to have little choice but to buttress its E&E industry as a bulwark against the volatility of the global commodities market.

Appendices

Appendix 2.1 Trade Channel – Formulas Based on Market-share Analysis

Approach	Detail Formula	Source
RCA index	See Balassa Index below Compare RCA of 1997/98 over 1992-93 between China and competitor country. A total of 50 products were compared based on China's top 50 products item.	Shafaeddin (2004)
Competitiveness Decomposed	ΔXij = ΔQi.sij + sij.Qi* (Δsij/sij - Δsik/sik) + Δsik/sik. sij.Qi "where *X* is exports and Δ is the absolute change in, *Qi* is total imports of *i* in the market concerned (at the end of the period), *sij* is the initial market share of country *j* in imports of *i* and with competitor country *k*, *sik* is *k*'s market share for product *i*." A positive result indicates market share gains, while a negative results shows loss of market share.	Roland-Holst and Weiss (2004) Further explanation is available in Weiss and Gao (2003)
Simultaneous equations	AFDI*it* = α + βPRC_FDI*t* + λx*it* + μ*i* + e*it* (1) PRC FD*It* = γ + δAFDI*it* + ρ*zt* + ν + w*t* (2) Here subscripts *i* and *t* refer to country *i* at time t; x*it* is the set of determinants of FDI to the Asian economies covered, so for country *i* its FDI inflow is AFDI*i*; *zt* is the set of determinants for FDI to PRC (PRC_FDI); u*i* and v are country specific terms; and e*i* and w are error terms.	Roland-Holst and Weiss (2005)
Balassa index	RCAij = (Xij/Xi) / (Xwj/Xw) "where *Xij* = value of country *i*'s export of commodity *j* *Xi* =value of country *i*'s total exports *Xwj* =value of world exports of commodity *j* *Xw*= value of world exports"	Abidin and Loke (2008)

Appendix 2.2 The Gereffi-Humphrey-Sturgeon Theory of Value Chain

Governance Type	Complexity of transactions	Codification of transactions	Competence of suppliers	Learning mechanisms within GVC
Market	Low	High	High	• Knowledge spill overs • Imitation
Modular	High	High	High	• Learning through pressure to accomplish international standards • Transfer of knowledge embodied in standards, codes, technical definition
Relational	High	Low	High	• Mutual learning from face-to-face interactions
Captive	High	High	Low	• Learning via deliberate knowledge transfer from lead firms confined to a narrow range of tasks – e.g. simple assembly
Hierarchy	High	Low	Low	• Imitation • Turnover of skilled managers and workers • Training by foreign leader/owner • Knowledge spill overs

Source: Pietrobelli and Rabellotti (2012, pp. 231.)

Appendix 3.1 List of E&E Product Codes under HS 1988/92 Nomenclature

No.	Product Code	Product Description
1	630110	Electric blankets
2	841451	Fans: table, roof etc. with a self-cont. electric motor
3	841460	Hoods having a maximum horizontal side not exceeding
4	841510	Air conditioning machines window or wall types,
5	841581	Air cond. Mach. Nes inc a ref unit and a valve for
6	841582	Air cond. Mach. Nes, inc a refrigerating unit
7	841583	Air cond. Mach. Nes, not incorporating refrigeration
8	841590	Parts of air conditioning machines
9	841810	Combined refrigerator-freezers, fitted with separate
10	841821	Refrigerators, household type, compression-type
11	841822	Refrigerators, household type, absorption-type,
12	841829	Refrigerators, household type, nes
13	841830	Freezers of the chest type, not exceeding 800 l
14	841840	Freezers of the upright type, not exceeding 900
15	841850	Other refrigerating or freezing chests, cabinets
16	841899	Parts of refrigerating or freezing equipment, n
17	841911	Instantaneous gas water heaters
18	841919	Instantaneous or storage water heaters, non-element
19	842112	Clothes-dryers, centrifugal
20	842211	Dish washing machines of the HH type
21	845011	Automatic washing machines, of a dry capacity < 10 kg
22	845012	Washing machines of a dry linen capacity =<10kg
23	845019	Household/laundry-type washing machines <10 kg, nes
24	845020	Household or laundry-type washing machines, cap >10kg
25	845090	Parts of household or laundry-type washing machine
26	845110	Dry-cleaning machines o/t hdg No 84.50
27	845121	Drying machines (o/t hdg No 84.50) each of a drum
28	845129	Drying machines (o/t No 84.50) nes
29	845210	Household type sewing machines
30	846910	Automatic typewriters and word-processing machine
31	846921	Typewriters, electric, weighing not more than 1
32	846929	Typewriters, electric, nes
33	847010	Electronic calculators operable with internal power
34	847021	Electronic calculators, printing, external power
35	847029	Electronic calculating machines, nes

No.	Product Code	Product Description
36	847030	Calculating machines, nes
37	847040	Accounting machines
38	847050	Cash registers
39	847090	Postage franking mchy ticket-issuing mchy etc
40	847110	Analogue or hybrid automatic data processing machine
41	847120	Digital auto data process machine
42	847191	Digital process units whether or not presented
43	847192	Computer input or output units
44	847193	Computer data storage units
45	847199	Automatic data processing machines and units, nes
46	847210	Office duplicating machines
47	847220	Addressing machines and address plate embossing
48	847230	Mchy for sorting or folding mail etc & mchy
49	847290	Office machines, nes
50	847310	Parts and accessories of typewriters and word-processing
51	847321	Parts and accessories of electronic calculating
52	847329	Parts and accessories of calculating & accounting
53	847330	Parts and accessories of automatic data process
54	847340	Parts and accessories of other office machines,
55	847611	Automatic goods-vending mach incorporating heating
56	847619	Automatic goods-vending machines, nes
57	847690	Parts of automatic goods-vending machine
58	850110	Electric motors of an output not exceeding 37.5
59	850120	Universal AC/DC motors of an output exceeding 3
60	850131	DC motors, DC generators, of an output < 750 watts
61	850132	DC motors, DC generators, of an output 0.75-75 kW
62	850133	DC motors, DC generators, of an output 75-375 kW
63	850134	DC motors, DC generators, of an output >375 kW
64	850140	AC motors, single-phase, nes
65	850151	AC motors, multi-phase, of an output < 750 Watts
66	850152	AC motors, multi-phase, of an output 0.75-75 kW
67	850153	AC motors, multi-phase, of an output > 75 kW
68	850161	AC generators (alternators), of an output < 75 kVA
69	850162	AC generators, of an output exceeding 75 KVA
70	850163	AC generators, of an output exceeding 375 KVA
71	850164	AC generators, of an output exceeding 750 KVA
72	850410	Ballasts for discharge lamps or tubes

No.	Product Code	Product Description
73	850421	Liquid dielectric transformers < 650 KVA
74	850422	Liquid dielectric transformers 650-10,000KVA
75	850423	Liquid dielectric transformers > 10,000 KVA
76	850431	Transformers electric, power capacity < 1 KVA, nes
77	850432	Transformers electric, power capacity 1-16 KVA, nes
78	850433	Transformers electric, power capacity 16-500 KVA
79	850434	Transformers electric, power capacity > 500 KVA, nes
80	850440	Static converters, nes
81	850450	Inductors, electric
82	850490	Parts of electrical transformers, static converter
83	850511	Metal permanent magnets, articles intended as magnets
84	850519	Permanent magnets & articles intended as magnets, nes
85	850520	Electro-magnetic couplings, clutches and brakes
86	850530	Electro-magnetic lifting heads
87	850590	Electro-magnets nes and parts of heading No 85.
88	850611	Manganese dioxide primary cell/battery volume < 300 c
89	850612	Mercuric oxide primary cell, battery, volume < 300 cc
90	850613	Silver oxide primary cells, batteries volume < 300 cc
91	850619	Primary cells, primary batteries nes, volume < 300 cc
92	850620	Primary cells, primary batteries nes, volume > 300 cc
93	850690	Parts of primary cells and primary batteries
94	850710	Lead-acid electric accumulators of a kind used
95	850720	Lead-acid electric accumulators nes
96	850730	Nickel-cadmium electric accumulators
97	850740	Nickel-iron electric accumulators
98	850780	Electric accumulators, nes
99	850790	Parts of electric accumulators, including separators
100	850810	Drills, hand-held, with self-contained electric
101	850820	Saws, hand-held, with self-contained electric motor
102	850880	Tools, nes, hand-held, with self-contained electric
103	850890	Parts of hand tools with self-contained electric
104	850910	Domestic vacuum cleaners
105	850920	Domestic floor polishers
106	850930	Domestic kitchen waste disposers
107	850940	Domestic food grinders and mixers; fruit or veg
108	850980	Domestic appliances, with electric motor, nes
109	850990	Parts of electro-mech. Domestic appliances

No.	Product Code	Product Description
110	851010	Shavers, with self-contained electric motor
111	851020	Hair clippers, with self-contained electric mot
112	851090	Parts of shavers and hair clippers, with self-contained
113	851110	Spark plugs
114	851120	Ignition magnetos, magneto-generators and magnet
115	851130	Distributors and ignition coils
116	851140	Starter motors
117	851150	Generators and alternators
118	851180	Glow plugs and other ignition or starting equip
119	851190	Parts of electrical ignition or starting equipment
120	851210	Lighting or 319nodized319 equipment of a kind used
121	851220	Lighting or visual 319nodized319 equipment nes
122	851230	Sound 319nodized319 equipment
123	851240	Windscreen wipes, defrosters and demisters
124	851290	Parts of electrical lighting, 319nodized319 and de
125	851310	Portable electric lamps designed to function by
126	851390	Parts of portable elect lamps designed to function
127	851610	Electric instantaneous or storage water heaters
128	851621	Electric space heating apparatus, having storage
129	851629	Electric space heating apparatus and electric s
130	851631	Electro-thermic hair dryers
131	851632	Electro-thermic hair-dressing apparatus, nes
132	851633	Electro-thermic hand-drying apparatus
133	851640	Electric smoothing irons
134	851650	Microwave ovens
135	851660	Ovens; cookers, cooking plates, boiling rings
136	851671	Electro-thermic coffee or tea makers, domestic,
137	851672	Electro-thermic toasters, domestic
138	851679	Electro-thermic appliances, domestic, nes
139	851680	Electric heating resistors
140	851690	Parts of electro-thermic apparatus, domestic, etc
141	851710	Telephone sets
142	851720	Teleprinters
143	851730	Telephonic or telegraphic switching apparatus
144	851740	Apparatus, for carrier-current line systems, ne
145	851781	Telephonic apparatus, nes
146	851782	Telegraphic apparatus, nes

No.	Product Code	Product Description
147	851790	Parts of electrical apparatus for line telephone
148	851810	Microphones and stands therefor
149	851821	Single loudspeakers, mounted in the same enclosure
150	851822	Multiple loudspeakers, mounted in the same enclosure
151	851829	Loudspeakers, nes
152	851830	Headphones, earphones and combined microphone/s
153	851840	Audio-frequency electric amplifiers
154	851850	Electric sound amplifier sets
155	851890	Parts of microphones, loudspeakers, headphones, earphones
156	851910	Coin or disc-operated record-players
157	851921	Record-players without loudspeaker, nes
158	851929	Record-players, nes
159	851931	Turntables with automatic record changing mechanism
160	851939	Turntables, nes
161	851940	Transcribing machines
162	851991	Sound reproducing apparatus, cassette type
163	851999	Sound reproducing apparatus, not incorporating
164	852010	Dictating mach not capable of operating without
165	852020	Telephone answering machines
166	852031	Magnetic tape rec incorporating sound reproducing
167	852039	Magnetic tape recorders incorporating sound rep
168	852090	Magnetic tape recorders and other sound recording
169	852110	Video recording or reproducing apparatus magnet
170	852190	Video recording or reproducing apparatus nes
171	852210	Pick-up cartridges
172	852290	Parts and accessories of apparatus of heading N
173	852510	Transmission apparatus for radio-teleph. Radio-broadcast
174	852520	Transmission apparatus, for radioteleph. Incorporating
175	852530	Television cameras
176	852610	Radar apparatus
177	852691	Radio navigational aid apparatus
178	852692	Radio remote control apparatus
179	852711	Radio receivers, portable, with sound reproduce/recording
180	852719	Radio broad receiver capable of op w/o an external
181	852721	Radio receiver not capable of op w/o ext source of

No.	Product Code	Product Description
182	852729	Radio receiver not capable of op w/o ext source of
183	852731	Radio broad receiver combined with sound record/rep
184	852732	Radio broad receiver not combined with sound recording
185	852739	Radio-broadcast receivers nes
186	852790	Radio reception apparatus nes
187	852810	Colour television receivers/monitors/projectors
188	852820	Television receivers an including video monitor
189	852910	Aerials and aerial reflectors of all kinds; par
190	852990	Parts for radio/tv transmit/receive equipment, nes
191	853010	Electrical 321nodized321, safety or traffic control
192	853080	Electrical 321nodized321, safety or traffic control
193	853090	Parts of electrical 321nodized321, safety or traffic
194	853110	Burglar or fire alarms and similar apparatus
195	853120	Indicator panels incorporating liquid crystal d
196	853180	Electric sound or visual 321nodized321 apparatus,
197	853190	Parts of electric sound or visual 321nodized321 apparatus
198	853210	Fixed capacitors designed for use in 50/60 Hz c
199	853221	Electrical capacitors, fixed, tantalum, nes
200	853222	Electrical capacitors, fixed, aluminium electro
201	853223	Electrical capacitors, fixed, ceramic dielectric
202	853224	Electrical capacitors, fixed, ceramic dielectric
203	853225	Electrical capacitors, fixed, dielectric of pap
204	853229	Electrical capacitors, fixed, nes
205	853230	Electrical capacitors, variable or adjustable (
206	853290	Parts of electrical capacitors
207	853310	Electrical resistors, fixed carbon, composition
208	853321	Electrical resistors fixed for a power handling
209	853329	Electrical resistors, fixed, other than heating
210	853331	Wirewound variable resistors, including rheostat
211	853339	Wirewound variable resistors, including rheostat
212	853340	Variable resistors, including rheostats and potentiometers
213	853390	Variable resistors, rheostats and potentiometers, nes
214	853400	Printed circuits
215	853510	Electrical fuses, for a voltage exceeding 1,000
216	853521	Automatic circuit breakers for a voltage exceeding
217	853529	Automatic circuit breakers, for a voltage exceeding
218	853530	Isolating switches and make-and-break switches,

No.	Product Code	Product Description
219	853540	Lightning arresters, voltage limiters and surge
220	853590	Electrical app for switching or protect electric circuits
221	853610	Electrical fuses, for a voltage not exceeding 1
222	853620	Automatic circuit breakers for a voltage not ex
223	853630	Electrical app for protecting electric circuits
224	853641	Electrical relays for a voltage not exceeding 6
225	853649	Electrical relays for a voltage exceed 60 V but
226	853650	Electrical switches for a voltage not exceeding
227	853661	Electrical lamp-holders, for a voltage not exceeding
228	853669	Electrical plugs and sockets, for a voltage not
229	853690	Electrical app for switching or protect electric circuits
230	853710	Boards, panels, including numerical control pan
231	853720	Boards, panels, including numerical control pan
232	853810	Boards, panels, etc for goods of heading 85.37
233	853890	Parts for use with the apparatus of heading no.
234	853910	Sealed beam lamp units
235	853921	Filament lamps, tungsten halogen
236	853922	Filament lamps, of a power not exceed 200 W and
237	853929	Filament lamps, excluding ultraviolet or infra-
238	853931	Fluorescent lamps, hot cathode
239	853939	Discharge lamps, other than ultra-violet lamps,
240	853940	Ultra-violet or infra-red lamps; arc lamps
241	853990	Parts of electric filament or discharge lamps
242	854011	Cathode-ray television picture tubes, including
243	854012	Cathode-ray TV picture tubes incl. video monitor
244	854020	Television camera tubes, image converter and other
245	854030	Cathode-ray tubes, nes
246	854041	Magnetron tubes
247	854042	Klystron tubes
248	854049	Microwave tubes, nes
249	854081	Receiver or amplifier valves and tubes
250	854089	Valve and tubes, nes
251	854091	Parts of cathode-ray tubes
252	854099	Parts of valve and tubes, nes
253	854110	Diodes, other than photosensitive or light emit
254	854121	Transistors, except photosensitive, < 1 watt
255	854129	Transistors, other than photosensitive transistor

No.	Product Code	Product Description
256	854130	Thyristors, diacs and triacs, other than photos
257	854140	Photosensitive semiconductor devices, photovoltaic
258	854150	Semiconductor devices, nes
259	854160	Mounted piezo-electric crystals
260	854190	Parts of mounted piezo-electric crystals and se
261	854211	Monolithic integrated circuits, digital
262	854219	Monolithic integrated circuits, nes
263	854220	Hybrid integrated circuits
264	854280	Electronic integrated circuits and microassemble
265	854290	Parts of electronic integrated circuits and mic
266	854310	Particle accelerators
267	854320	Signal generators
268	854330	Machines & apparatus for electroplating, electric
269	854380	Electrical machines and apparatus, having individual
270	854390	Parts of electrical machines & apparatus having
271	854411	Insulated (including 323nodized or 323nodized) win
272	854419	Insulated (including 323nodized or 323nodized) win
273	854420	Co-axial cable and other co-axial electric conductor
274	854430	Ignition wiring sets & oth. Wiring sets of a kind
275	854441	Electric conductors, for a voltage not exceeding
276	854449	Electric conductors, for a voltage not exceeding
277	854451	Electric conductors, for a voltage >80V but=<1,0
278	854459	Electric conductors, for a voltage >80V but not
279	854460	Electric conductors, for a voltage exceeding 1,
280	854470	Optical fibre cables, made up of individually
281	854511	Carbon or graphite electrodes, of a kind used
282	854519	Carbon or graphite electrodes, of a kind used
283	854520	Carbon or graphite brushes
284	854590	Art. Of carbon or graphite, of a kind used
285	854610	Electrical insulators of glass
286	854620	Electrical insulators of ceramics
287	854690	Electrical insulators, nes
288	854710	Insulating fittings of ceramics for elec. Machine
289	854720	Insulating fittings of plastics for elec. Machine
290	854790	Insulating fittings for electrical mach appliance
291	854800	Electrical parts of machinery and apparatus, nes
292	900610	Cameras of a kind used for preparing printing p

No.	Product Code	Product Description
293	900620	Cameras of a kind used for recording doc on mic
294	900630	Cameras designed for special use, underwater
295	900640	Instant print cameras
296	900651	Cameras, single lens reflex, for roll film of a
297	900652	Cameras for roll film of a width less than 35 m
298	900653	Cameras for roll film of a width of 35 mm, nes
299	900659	Photographic, other than cinematographic camera
300	900661	Photographic discharge lamp (electronic) flashlight
301	900662	Flashbulbs, flashcubes and the like
302	900669	Photographic flashlight apparatus, nes
303	900691	Parts and accessories for photographic cameras
304	900699	Parts and accessories for photographic flashlight
305	900711	Cinematographic cameras for film of < 16 mm wide
306	900719	Cinematographic cameras, nes
307	900721	Cinematographic projectors for film of less that
308	900729	Cinematographic projectors, nes
309	900791	Parts and accessories for cinematographic camera
310	900792	Parts and accessories for cinematographic projector
311	900810	Slide projectors
312	900820	Microfilm, microfiche or other microform reader
313	900830	Image projectors, nes
314	900840	Photographic enlargers and reducers
315	900890	Parts and access of image projectors, enlargers
316	900911	Electrostatic photo-copying apparatus, direct
317	900912	Electrostatic photo-copying apparatus, indirect
318	900921	Photo-copying apparatus, incorporating an optic
319	900922	Contact type photo-copying apparatus, nes
320	900930	Thermo-copying apparatus
321	900990	Parts and accessories for photo-copying apparatus
322	901010	Apparatus and equip for automatically developing
323	901020	Apparatus and equipment for photographic
324	901030	Projection screens
325	901090	Parts and accessories for apparatus and equipment
326	901811	Electro-cardiographs
327	901819	Electro-diagnostic apparatus, nes
328	901820	Ultra-violet or infra-red ray apparatus
329	902211	Medical X-ray apparatus

No.	Product Code	Product Description
330	902219	Apparatus based on the use of X-rays for other
331	902221	Apparatus based on the use of alpha beta or gam
332	902229	Apparatus based on the use of alpha beta or gam
333	902230	X-ray tubes
334	902290	Parts and accessories for app based on the use
335	902710	Gas or smoke analysis apparatus
336	902720	Chromatographs and electrophoresis instruments
337	902730	Spectrometers, spectrophotometers and spectrograph
338	903020	Cathode-ray oscilloscopes and cathode-ray oscilloscopes

Source: UNComtrade

Appendix 3.2 List of MSIC Codes for E&E Sector in Malaysia

MSIC	Description
25206	Manufacture of plastic injection moulded components
26100	Manufacture of glass and glass products
26910	Manufacture of non-structural non-refractory ceramic ware
29191	Manufacture of air-conditioning, refrigerating and ventilating machinery
29220	Manufacture of metal-forming machinery and machine tools
29290	Manufacture of other special-purpose machinery n.e.c.
29300	Manufacture of domestic appliances n.e.c
30001	Manufacture of office and accounting machinery
30002	Manufacture of computers and computer peripherals
31100	Manufacture of electric motors, generators and transformers
31200	Manufacture of electricity distribution and control apparatus
31301	Manufacture of telecommunication cables and wires
27320	Manufacture of other electronic and electric wires and cables
31400	Manufacture of batteries and accumulators
31500	Manufacture of lamps & lighting equipment
31900	Manufacture of other electrical equipment n.e.c.
32101	Manufacture of semi-conductor devices
32102	Manufacture of electronic valves and tubes and printed circuit boards
32109	Manufacture of other electronic components
32200	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
32300	Manufacture of television and radio receivers sound or video recording or reproducing apparatus, and associated goods
33110	Manufacture of medical and surgical equipment orthopaedic appliances
33120	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
33202	Manufacture of photographic equipment

Source: Department of Statistics, Malaysia

Appendix 3.3 List of E&E Products in 4-digit level of HS 1988/92 Nomenclature

Product Code		
8415	8517	8538
8450	8518	8539
8470	8519	8540
8471	8520	8541
8472	8521	8542
8473	8522	8543
8476	8525	8544
8501	8526	8545
8504	8527	8546
8505	8528	8547
8506	8529	8548
8507	8530	9006
8508	8531	9007
8509	8532	9008
8510	8533	9009
8511	8534	9010
8512	8535	9022
8513	8536	
8516	8537	

Source: UNComtrade

Appendix 3.4 Guided Interview Schedule for MNC

Name of Interviewee :	Date :
Title :	Place of Interview :
Organisation :	Department :

1. Basic Information
What products do you make?
Date established in Malaysia? What are the sales per year? No. of Employees?
2. Direct relationship with China
Do you import inputs from China? How much from China vs. local inputs?
Price difference (per unit) between local inputs vs. Chinese inputs? Quality of Chinese inputs, comparable to local/US/Japan/Korea?
Do you export to China? What products? What proportion of total sales coming from China vs. Europe/Japan/US/Local?
What kind of relationship do you have with China vendors? Contractual (buying when you need) or Networked (work together), hierarchical (get technical assistance from you, to deliver the right goods)?
If you sell to China, do you have a contractual relationship, based on arm's length (tender each time for lowest price), or do you sell to someone you know most of the time, or do you sell through a subsidiary in China?
3. GVC/GPN question
If you have a subsidiary in China, who is reporting to whom? China report to Malaysia or Malaysia report to China? Of both Malaysia and China office report to Singapore/US/Japan HQ?
What kind of functions the Malaysia plant performs? (assembly and testing, regional HQ, finance, R&D?) ask for evidence – what product development?
What kind of functions the China office perform (assembly and testing, regional HQ, finance, R&D) – ask for evidence – what product development?
Have you collaborated on any joint project, Malaysian plant with Chinese plant? When? How? What? Was it successful?
If function includes R&D, ask for more details, what kind of R&D chip design or process technology, or some minor R&D.

Do you face pressure to move your Malaysian plant in relation to China? What kind of pressure? (Price/Cost or Capability (HR) or Location or Eco-system (Innovation)
What are the strengths of Chinese colleagues compared to Malaysian plant? What are Malaysian operations' strengths?
What are the weaknesses/limitations of Chinese colleagues compare to Malaysian plant? What is Malaysian operations weakness/limitation?
How does China affect your operations? (ask for positive and negative) What do you see the future of China plant vs. Malaysia plant in the medium term (5 years)?
What is your strategy for adaptation/survive, when faced with competition from China?
4. Competition in 3rd Market
If you do not have a subsidiary in China, do you face competition from Chinese products in your export market (to US, Europe or Japan)?
If yes, which product? In which market destination?
What do you think about your competitors in China? (quality, price, marketing)
How to adjust to Chinese competition? – Ask for evidence, e.g. programme, expenditure.
5. Import Penetration (small electrical appliances)
For the Malaysian market, who are your main competitors for the products that you make and sell? (are they from China?)
Which product is especially affected?
How does China affects your firm? In medium and long term? (upgrading prospects)
6. Policy
Are they anything you think the Government to help you mitigate the impact? Past programme that works? Suggest programmes?

Appendix 3.5 Guided Interview Schedule for Tier1/Tier 2 Suppliers to MNC

Name of Interviewee :	Date :
Title :	Place of Interview :
Organisation :	Department :

1. Basic Information
What products do you make?
Date established in Malaysia? What are the sales per year? No. of Employees?
2. Direct relationship with MNC
What percentage of your sales is attributable to the MNC?
Other than this MNC, do you sell to other buyers? Where they are from?
For the MNC, do they provide technical assistance to you on how improve your technology in production? (Ask for evidence -programme/funding)
How would you describe your relationship with the MNC? Equal footing/dependent/networked
Do you provide ideas for new product development of your MNC client?
3. Question on China (in Malaysia operations)
Do you face competition from China, where the MNC you are working with now source the parts you have been supplying from China?
What is the competitiveness of China's suppliers? Price or quality or both?
What is your counter strategy?
Do you import inputs from China/elsewhere? How much from China vs. local inputs?
Price difference between local inputs vs. Chinese inputs? Quality of inputs?
Do you export to China? What product? What proportion of total sales coming from China vs. Europe/Japan/US/Local?
What kind of relationship do you have with China vendors? Contractual (buying when you need) or Networked (work together), hierarchical (get technical assistance from you, to deliver the right goods)?

4. Competition in 3rd Market (beyond Malaysian operations)
Do you supply to markets beyond Malaysia, do you face competition from China products in your export market (for intermediate goods to China, US, Europe or Japan)?
If yes, which product? In which market destination?
What do you think about your competitors in China? (quality, price, marketing)
How do you adjust to China's competition? – Ask for evidence, e.g. programme, expenditure.
5. GVC/GPN
How that China does affect you? In medium and long term. (upgrading prospects)
6. Policy
Are they anything you think the Government can do to help you mitigate the impact? Past programme that works? Suggest programmes?

Appendix 3.6 Guided Interview Schedule for Government Agencies

Name of Interviewee :	Date :
Title :	Place of Interview :
Organisation :	Department :

1. Basic Information
How do you view China's impact on Malaysian manufacturing as a whole?
Your view on specifically for E&E?
Is China a significant factor when you plan the industry development/ or is China factor not significant?
2. Policy
What is the policy? To counter China's impact?
Is there any programme? How much is the spending?
[For MIDA] Is there any other programme specifically tailored for China, like Malaysia China Kuantan Industrial Park?
Any measurement on the progress?
3. Future
How do you see China's impacting your industries? On MNCs? On SMEs in Malaysia in 5 years' time?
Note: Look out for interviewees if they mention "upgrading"/ "up-scaling".

Appendix 3.7 Guided Interview Schedule for China Electronics Players (Non-Western/Japanese/NiC MNC)

Name of Interviewee:	Date : 2014
Title :	Place of Interview:
Organisation :	Department :

Companies Information
1. What are the main functions your plant? Manufacturing/R&D/HQ Functions?
2. Number of employees in your plant/office? Out of total headcount, how many R&D staff?
3. Where is your source of inputs? Local or Overseas? % of local inputs in total inputs for one output. What are the local inputs like (what kind of material)? (Minor or major)
4. If overseas, which component is from overseas? Where do you source them? Malaysia/ASEAN-4, or Taiwan, Japan/USA/Europe? How do you buy them, purchase when you need by contract (arms-length transaction), by long-term relationship (repeat order) like a partner, buy from subsidiary.
5. If you import from Malaysia, what product, how it changes over time?
6. If you currently do not buy from Malaysia? Why?
7. Is there anything the Malaysian side can do to make you consider purchasing from Malaysia? What are the factors you consider? Price/Delivery/Quality/ More Information about Malaysia.
8. Do you produce just for local markets or you export? If exports, where do you ship your products? If too many destinations, focus on the top 3 main products that you do by revenue? To the US/EU directly or to China first before re-exporting? Any figures that you can share, revenue or units of shipment?
9. What is your main activity in production? Assembly and packaging only or includes design new products?
10. Which product is the main revenue earner at company level? If includes design, where is it being designed and produced? (China or overseas)
Continue to Q11 to Q14 if respondents answer YES to product design

11. Does your company import technology from any companies as technology partners? What kind of relationship you have with technology partners? Equal partnership/hierarchical/contractual (only when needed-purchase the technology) Mainly from which country? Anyone from Malaysia? 12. Does your company do its own complete design work until a product is launched? (the whole chain –design, prototyping- mass production). All done in-house or you cooperate with some other companies to bring new products to the market? Can you give some example of the products roll out from your company/plant?
13. Alternatively (how much spending on R&D) How much % of revenue is plough back into R&D?
14. If you do R&D, what kind of IP is coming out from centre, processing technology or fundamental design of chips/equipment?
Continue here if respondent answer No to Design Works in Q10
15. Is there any plan to upgrade, how do you plan to upgrade your technology in the market you are producing?
16. Which product space your company will be moving into the future? How can Malaysia capture some of the action in the next big wave (inflexion point), knowing the capability here?
17. At your firm level, why do you think China as an industry move so fast up the value chain in global electronics industry? What is the critical success factor?
18. What are the challenges your company is facing?
19. How is your company responding to those challenges?
Question on Malaysia/South-east Asia
20. For trade, how does your company handle competition at the exports markets? And in which product specifically?
21. Who are your main competitors (at export markets) or (local markets) with some reference to geographical location?
22. Do you see any synergies that can be tapped between China, with Malaysia in terms of Electronics industry operations that are ongoing? If yes, can you give some detail example?
23. How do you view country like Malaysia from your organisation? Threat (competitor) or opportunity or something else that you think is relevant?
Investment Questions
24. What is your view on Malaysia as an investment destination? If you are not familiar with Malaysia, what is your view on Southeast Asia?

25.	[Question for Chinese MNCs] For organizational dynamics, what is the role your overseas operations in the scheme of things? What are their functions within your family of plants/offices. How are the plants ranked? Which is the centre of reporting in East Asia for your company?
26.	Can your overseas offices(if any) make decisions with regards to innovation or they have to seek approval from HQ?
27.	Which unit/manager decides where to invest in overseas destination? What is your main motivation when you invest overseas? Cheaper labour/costs of production/ expand your market for your products/ purchase technology?

-------- end of interview-------

Appendix 4.1 Unit Value for Monolithic Digital Circuits, Non-Digital (HS 854219)

Year	Malaysia Unit Value (US$)	China Unit Value (US$)	Price Diff
1992	0.80	0.42	0.38
1993	0.84	0.10	0.74
1994	0.82	0.09	0.73
1995	0.94	0.40	0.54
1996	0.89	0.31	0.58
1997	2.34	0.28	2.07
1998	0.61	0.30	0.31
1999	0.75	0.33	0.42
2000	0.68	0.41	0.27
2001	0.76	0.36	0.40
2002	0.79	0.27	0.52
2003	0.92	0.18	0.74
2004	0.80	0.18	0.63
2005	0.85	0.16	0.69
2006	1.06	0.18	0.88
2007	0.62	0.16	0.46
2008	0.58	0.13	0.45
2009	1.14	0.12	1.02
2010	0.66	0.11	0.55
2011	0.77	0.45	0.32
2012	0.86	0.61	0.25
2013	-	-	-

Note: Price/Quantity not available as quantity data is not available for year 2013

Source: Own Calculations based on UNComtrade

Appendix 4.2 Unit Value for Parts for Integrated Circuit (HS 854290)

Year	Malaysia Unit Value (US$)	China Unit Value (US$)	Difference
1992	0.12	-	-
1993	0.09	-	-
1994	0.06	17.88	-17.81
1995	0.05	34.11	-34.06
1996	0.10	38.23	-38.13
1997	70.98	122.36	-51.37
1998	35.58	121.68	-86.10
1999	1.52	55.26	-53.74
2000	9.50	34.87	-25.36
2001	1.69	39.84	-38.15
2002	52.72	29.70	23.03
2003	73.68	26.89	46.80
2004	20.53	36.24	-15.71
2005	27.40	29.62	-2.22
2006	1.76	30.22	-28.46
2007	76.92	37.46	39.46
2008	119.23	43.35	75.88
2009	17.71	41.63	-23.92
2010	3.10	42.89	-39.79
2011	114.19	49.89	64.30
2012	112.83	50.95	61.88
2013	-	52.41	-

Source: Own Calculations based on UNComtrade

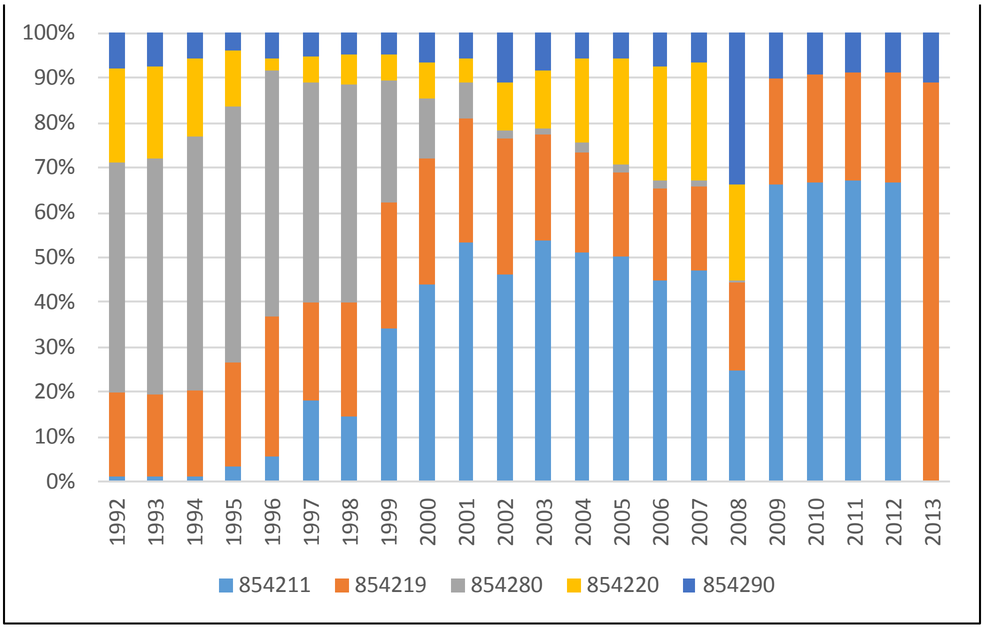
Appendix 4.3 Statistical Results of Two Means Hypothesis Testing of Price/Quantity Ratio for Monolithic Digital Circuits (HS8542)

t-Test: Two-Sample			t-Test: Two-Sample		
854211 (Monolithic integrated circuits, digital)					
at 0.05 significant level			at 0.01 significant level		
	M'sia P/Q	Chn P/Q		M'sia P/Q	Chn P/Q
Mean	0.8157	0.5685	Mean	0.8157	0.5685
Variance	0.1295	0.0746	Variance	0.1295	0.0746
Observations	21	21	Observations	21	21
Pooled Variance	0.1021		Pooled Variance	0.1021	
Hypothesized Mean Difference	0		Hypothesized Mean Difference	0	
df	40		df	40	
t Stat	2.5073		t Stat	2.5073	
P(T<=t) one-tail	0.0082		P(T<=t) one-tail	0.0082	
t Critical one-tail	1.6839		t Critical one-tail	2.4233	
P(T<=t) two-tail	0.0163		P(T<=t) two-tail	0.0163	
t Critical two-tail	2.0211		t Critical two-tail	2.7045	
854219 (Monolithic integrated circuits, except digital)					
t-Test: Two-Sample			t-Test: Two-Sample		
at 0.05 significant level			at 0.01 significant level		
	M'sia P/Q	Chn P/Q		M'siaP/Q	Chn P/Q
Mean	0.8800	0.2636	Mean	0.8800	0.2636
Variance	0.1320	0.0199	Variance	0.1320	0.0199
Observations	21	21	Observations	21	21
Pooled Variance	0.0759 6		Pooled Variance	0.0759 6	
Hypothesized Mean Difference	0		Hypothesized Mean Difference	0	
df	40		df	40	
t Stat	7.2469		t Stat	7.2469	
P(T<=t) one-tail	0.0000		P(T<=t) one-tail	0.0000	
t Critical one-tail	1.6839		t Critical one-tail	2.4233	
P(T<=t) two-tail	0.0000		P(T<=t) two-tail	0.0000	
t Critical two-tail	2.0211		t Critical two-tail	2.7045	

854290 (Parts of Electronic Integrated Circuits)					
t-Test: Two-Sample Assuming Unequal Variances			t-Test: Two-Sample Assuming Unequal Variances		
at 0.05 significant level			at 0.01 significant level		
	M'sia P/Q	Chn P/Q		M'sia P/Q	Chn P/Q
Mean	35.23	46.77	Mean	35.23	46.77
Variance	1797.4 3	748.40	Variance	1797.4 3	748.40
Observations	21	20	Observations	21	20
Hypothesized Mean Difference	0		Hypothesized Mean Difference	0	
df	34		df	34	
t Stat	-1.041		t Stat	-1.041	
P(T<=t) one-tail	0.153		P(T<=t) one-tail	0.153	
t Critical one-tail	1.691		t Critical one-tail	2.441	
P(T<=t) two-tail	0.305		P(T<=t) two-tail	0.305	
t Critical two-tail	2.032		t Critical two-tail	2.728	

Source: Own Calculations based on UNComtrade

Appendix 4.4 Share of the products at 6 digits level to the Malaysian Total Exports of Integrated Circuits (HS8542)



Note: HS Code 854280 and HS Code 854220 become unavailable from 2008 onwards.

Source: Own Calculations based on UNComtrade

Appendix 4.5 Wafer Fabrication Plants in Malaysia (Front-end Players)

Company	Country of Origin	State	Capacity	No. of Worker	Target Market
Silterra	Malaysian–State-owned	Kedah	Approximately 40,000 wafers per month	N.A.	CMOS, Mixed signal RF chips, High Voltage, MEMS Chips, 200mm wafer chips facility.
Infineon	German	Kedah	Approx. 100,000 wafers per month, announced plan to double capacity in 2012, with additional investment of RM350million in Kulim	1,500	Automotive IC and power plant IC
X-fab	Germany	Sarawak	Approx. 72,000 eight inch equivalent wafer starts per month	N.A.	1.0 to 0.13 µm mixed-signal, CMOS and BiCMOS and special SOI and MEMS long lifetime processes for automotive, industrial and medical applications

N.A. = Not available

Source: Multiple Sources based on corporate webpages

Appendix 4.6 Ownership structure of manufacturing firms in Penang, as of August 2008

	Firms (%)	Sales (%)	Employment (%)
Foreign-owned	22.9	85.6	72.3
Large	11.3	82.0	68.3
SMEs	11.6	3.6	3.9
Local	77.1	14.4	27.7
Large	9.7	9.3	12.6
SMEs	67.4	5.1	15.2
	100	100	100

A large firm is defined as having annual sales revenue of RM25 million and employ more than 150 people. SMEs are defined as having sales below RM25 million and employ less than 150 people.

N=629

Source: Athukorala (2012, pp. 26. Citing Penang Industrial Survey 2007 conducted by Invest Penang)

Appendix 4.7 Merchandise exports from Penang: value, composition and share of total Malaysian exports

	1990-1*	1995-6*	2000-1*	2005-6*	2007	2008	2009
Exports, US$ bn	18.7	58.0	75.5	113.4	127.2	110.8	111.3
Composition (%)							
Manufacturing	88.9	93.8	96.6	96.2	95.8	95.8	96.8
Others	11.1	6.2	3.4	3.8	4.8	4.2	3.2
Total	100	100	100	100	100	100	100
Share of Penang in total Malaysian exports (%)							
Primary products	9.2	9.1	8.2	9.5	8.1	5.8	5.5
Food beverages and tobacco	14.6	10.8	10.3	11.4	11.9	9.4	10.1
Crude materials	6.7	10.4	11.8	16.9	15.3	14.4	13.0
Animal and vegetable oils and fats	10.7	7.2	4.4	4.0	3.6	1.8	1.3
Manufacturing	31.4	28.5	33.9	37.4	37.4	39.6	38.5
Chemicals	15.5	14.8	16.1	12.2	12.7	10.6	12.0
Resource-based manufactured goods	29.0	18.0	16.1	15.0	15.5	14.8	14.1
Machinery and transport equipment	30.6	31.4	38.1	44.0	44.8	53.0	47.4
Miscellaneous manufacturing articles	40.4	29.1	29.5	34.6	36.2	34.2	35.7

Source: Adapted from Athukorala (2012, pp. 30.)

Appendix 4.8 Top 25 foreign enterprises in Penang (as at August 2008)

	Company[1]	Home country	Employment	Years in operation	Activities in Penang
1	Intel Technologies	USA	10,304 (incl. employees in Kulim)	>35	Motherboards
2	Flextronics Technology	Singapore	7,000	15-20	PCBA and system integration, failure Analysis, supply chain solution
3	Motorola Technologies	USA	4,811	25-30	2-way radios, wireless broadband communication equipment and accessories
4	B Braun Medical Industries	Germany	4,700	25-30	Medical and surgical equipment and related services
5	WD Media (formerly Komag)	USA	4,569	15-20	Thin film magnetic disks and plated polished substrates
6	Dell	USA	4,500	12-15	Computer assembly and world-wide customer service
7	Jabil Circuit	USA	4,207	20-25	Electronic manufacturing services
8	Canon Electronics	Japan	3,805	5-10	Magnetic heads and component cameras
9	Sony	Japan	3,750	20-25	Consumer electronics
10	Renesas Semiconductor (formerly Hitachi Semiconductor)	Japan	3,700	>35	Linear and digital integrated circuits, power transistors and transistor diodes

	Company[1]	Home country	Employment	Years in operation	Activities in Penang
11	Plexus Manufacturing	USA	3,389	10-15	Computer peripherals and PCBs
12	Agilent Technologies (formerly Hewlett Packard)	USA	3,358	>35	Microwave devices, test accessories, amplifiers, transceivers and test
13	Fairchild Semiconductor (formerly National Semiconductor) - To be sold- announced in 2015	USA	2,980	>35	Semiconductor back-end manufacturing and admin. and engineering services
14	Kobe Precision	Japan	2,740	15-20	Ground aluminium substrate
15	Seagate Penang	USA	2,733	20-25	Hard disk drives
16	Osram Opto Semiconductors	Germany	2,731	>35	light emitting diodes
17	ASE Electronics	Taiwan	2,530	20-25	Integrated circuit packaging, testing, and turnkey services
18	Sanyo Automedia	Japan	2,080	20-25	Car radios and CD-changers
19	Robert Bosch	Germany	2,000	>35	Car parts and automotive semiconductors
20	Philips Lumileds	Netherlands	1,600	10-15	High-power LED lighting and solid state lighting solutions
21	Sanmina Science Systems	USA	1,203	10-15	PCBA and system integration

	Company[1]	Home country	Employment	Years in operation	Activities in Penang
22	Linear Semiconductor	USA	1,167	10-15	Integrated circuits
23	Avago Technologies	USA	961	>35	Analogue, mixed-signal and optoelectronic components and wafer fabrication
24	Altera	USA	950	15-20	R&D relating to VLSI design, layout, test and software development
25	Advanced Micro Devices	USA	896	>35	Integrated circuits

Source: Athukorala (2012, pp. 27 and pp. 28.)

Appendix 4.9 Major Electrical Manufacturer in Malaysia by Domestic Market Share in- Japanese and Korean Electrical MNCs

Company	Year Established in Malaysia	Location	Major Products
Multinationals			
Japanese			
Panasonic Malaysia*	1988	Selangor	TV, Air Condition, Kitchen Appliances
Sony ECMS	1980s	Selangor	TVs
Sanyo PT Malaysia	1987	Johor	Hi Technology Mobile Phones
Sharp Electronics	1989	Johor	TV
	1985	Selangor	Marketing Arm for Sharp products in Malaysia
	1995	Selangor	International Procurement Centre
	2009	Selangor	Sharp Electronics Malaysia established to undertake R&D jobs in Malaysia.
Mitsubishi Electric	1989	Johor	DVD recorders, printers
JVC Video Malaysia*	1988	Selangor	Digital Camcorder
Hitachi Electric Products Malaysia	1988	Selangor	Optical data storage device
Korean			
Samsung SDI	1989	Selangor	Cathode tube, microwave tube production
Samsung Electron Devices, Samsung Corning and Samsung Electronic Display	1997	Negeri Sembilan	LCD, TFT display, batteries

Company	Year Established in Malaysia	Location	Major Products
Malaysian-owned			
Pensonic	1994	Penang	Wide range of small appliances including small radios, blenders, microwave ovens and some major appliances like washing machines
Khind			Rice Cooker
Alpha	1990	Selangor	Water Heater
Joven	1990	Selangor	Water Heater
Milux	2006	Klang	Gas cookers, ceiling fans, water heaters, oven toasters.

Note: * Announced exit of manufacturing in 2015, Panasonic to streamline TV manufacturing to China, JVC announced exit of the camcorder business. While LG is a significant player at retail market of Malaysian electrical scene for TV and air-condition but does not have manufacturing facility in Malaysia.

Source: Edgington and Hayter (2013) and various sources

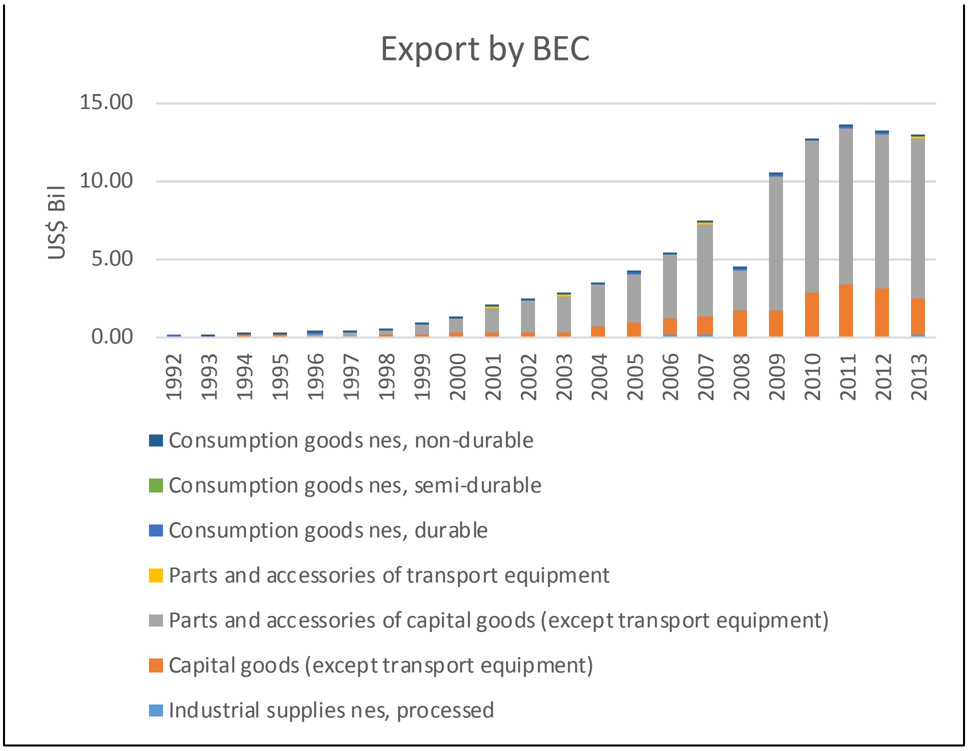
Appendix 5.1 Balance of Trade between Malaysia and China for Semiconductors (HS 8542) – Malaysia as Reporter

	Values in US$ Bn																					
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total Exp	0.00	0.00	0.00	0.01	0.02	0.04	0.15	0.13	0.14	0.5	0.9	1.3	1.4	1.8	2.6	4.1	0.9	7.0	5.9	8.0	8.0	8.4
Total Import	0.00	0.00	0.00	0.00	0.02	0.03	0.02	0.04	0.10	0.2	0.5	0.5	0.8	1.3	1.8	2.2	1.1	2.0	1.6	1.9	3.9	4.8
Balance for 8542	0.00	0.00	0.00	0.01	0.00	0.01	0.13	0.09	0.04	0.2	0.4	0.8	0.7	0.6	0.8	1.9	-0.2	5.0	4.4	6.0	4.1	3.7

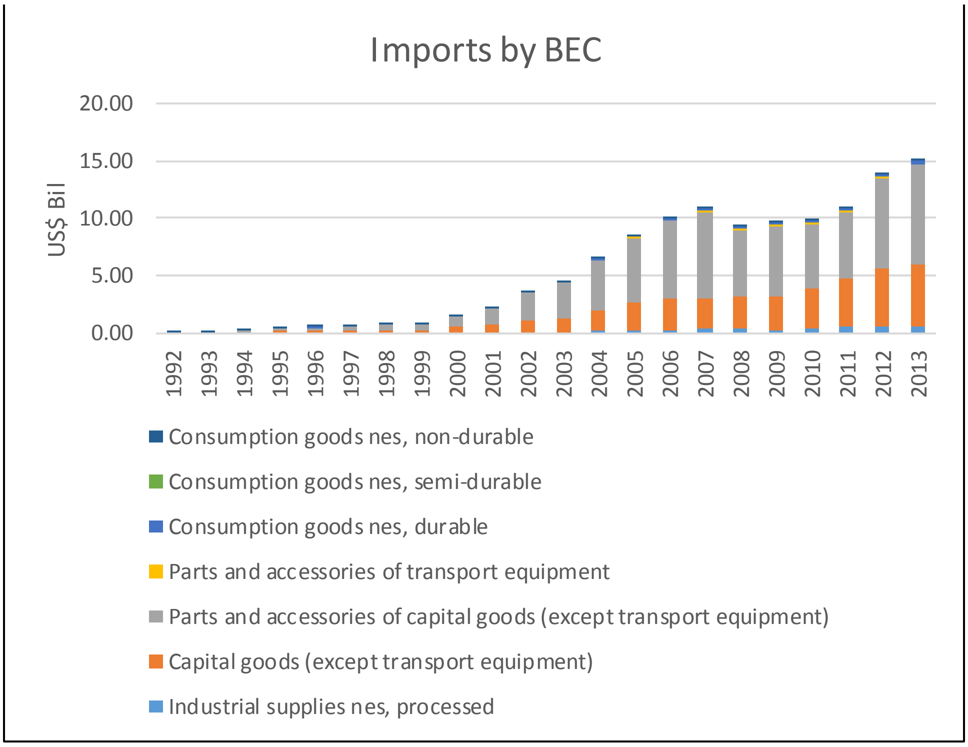
Note: the value for all cells from 1992-1995 is not zero, but because the numbers here are shown in US$ Billion, the initial years volume is too low when denominated in billion dollars.

Source: Own Calculation based on UNComtrade

Appendix 5.2 Malaysia Bilateral Exports and Imports with China by BEC Classification, Malaysia as Reporter



Source: UNComtrade



Source: UNComtrade

Appendix 5.3 Differences of Sum of HS Codes under BEC 42 Code with Total BEC 42 Code (Malaysia as reporter)

	Values are in US$ Bn																				
Export	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
HS Code Total	0.01	0.02	0.04	0.1	0.1	0.2	0.3	0.6	0.9	1.6	2.0	2.3	2.7	3.2	4.0	5.9	2.5	8.6	9.7	10.1	9.9	10.2
BEC Total	0.01	0.02	0.1	0.1	0.2	0.2	0.3	0.6	0.9	1.6	2.1	2.4	2.9	3.3	4.3	6.1	2.7	8.9	10.1	10.5	10.4	10.6
Difference	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.02	-0.03	-0.04	-0.1	-0.1	-0.1	-0.1	-0.2	-0.1	-0.2	-0.2	-0.5	-0.4	-0.5	-0.4
Import	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
HS Code Total	0.03	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.9	1.3	2.4	3.1	4.4	5.5	6.7	7.5	5.8	6.2	5.6	5.9	7.9	8.7
BEC Total	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.9	1.3	2.5	3.3	4.7	5.9	7.0	7.9	6.4	6.8	6.4	7.0	9.1	10.2
Difference	-0.01	-0.02	-0.02	-0.04	-0.1	-0.1	-0.04	-0.04	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.3	-0.5	-0.6	-0.6	-0.8	-1.1	-1.1	-1.4

Source: Own Calculation based on UNComtrade

Appendix 5.4 List of Parts and Components in HS Codes Classified as Parts and Components (except transport equipment) (BEC code 42)

Product Code				
841590	853310	853661	854129	900792
841899	853321	853669	854130	900990
845090	853329	853690	854140	
847310	853331	853710	854150	
847321	853339	853720	854160	
847329	853340	853810	854190	
847330	853390	853890	854211	
847340	853400	854011	854219	
847690	853510	854012	854220	
850490	853521	854020	854280	
850890	853529	854030	854290	
851790	853530	854041	854390	
851890	853540	854042	854511	
852210	853590	854049	854519	
852290	853610	854081	854520	
852910	853620	854089	854590	
852990	853630	854091	854610	
853090	853641	854099	854620	
853190	853649	854110	854800	
853290	853650	854121	900791	

Source: UNComtrade

Appendix 5.5 Malaysian E&E Trade Balance with China, Malaysia as Reporter

	US $ Bn								
	1992	1993	1994	1995	1996	1997	1998	1999	2000
Trade Balance	-0.04	-0.02	-0.02	-0.2	-0.3	-0.3	-0.2	0.0	-0.3

	US$ Bn							
	2001	2002	2003	2004	2005	2006	2007	2008
Trade Balance	-0.2	-1.3	-1.7	-3.0	-4.3	-4.6	-3.5	-5.0

	US$ Bn				
	2009	2010	2011	2012	2013
Trade Balance	0.8	2.8	2.6	-0.7	-2.2

Source: Own Calculation based on UNComtrade

Appendix 5.6 Manual Matching of Codes for Import and Export Component of MSIC Code 32101 and 32102

HS Codes	MSIC	HS Codes	MSIC	HS Codes	MSIC
853210		853310			
853221		853321			
853222		853329			
853223		853331			
853224		853339			
853225		853340			
853229		853390			
853230		853400			
853290		854011			
854110	32101	854012	32102		32109*
854121		854020			
854129		854030			
854130		854041			
854140		854042			
854150		854049			
854160		854081			
854190		854089			
854211		854091			
854219		854099			
854220					
854280					
854290					

Note: 32109 MSIC Code are not assigned the HS Codes trade data due to very minimal share (7% of total MSIC 3210 at 4 digit level for entire 1997-2013 period) in the product code HS8542 code at 4-digit level. The HS 2002 to ISIC Rev.3 Code Concordance table provides concordance up to 4-digit level of ISIC, whereas Malaysian MSIC codes, goes up to 5-digit. Most MSIC codes 5 digit codes are achieved just by adding an extra digit of 0 at the back of ISIC code. For semiconductors, however, this is not the case, therefore some manual judgement is exercised.

Source: Own elaboration based on Concordance Table HS 2002 Nomenclature to ISIC Code Rev. 3 provided by Worldbank WITS Database

Appendix 6.1 Top Malaysian E&E Products in Competitive, Mutual Expansion and Reverse Competitive Relationship with Chinese E&E Exports by 2012 for US Market

Top 10 Products in 2002 that turns Competitive by 2012						
		2002		2012		
Product Code	Products Description	US$ Bn	% of E&E	US$ Bn	% of E&E	% Diff
847120	Digital computers with cpu and input-output units	2.9	14.7	0.3	1.5	-13.2
847192	Input or output units, whether or not presented	1.7	8.7	0.2	1.2	-7.5
852810	Colour television receivers/monitors/projectors	1.3	6.6	0.02	0.1	-6.5
847330	Parts and accessories of automatic data process	2.2	11.0	1.0	6.2	-4.9
847193	Computer data storage units	2.0	10.0	1.0	6.1	-3.9
851710	Telephone sets	0.4	2.0	0.1	0.8	-1.2
852110	Video recording or reproducing apparatus magnet	0.4	1.8	0.1	0.9	-1.0
851740	Apparatus, for carrier-current line systems, ne	0.2	0.8	0.01	0.04	-0.8
852739	Radio-broadcast receivers nes	0.2	1.1	0.1	0.4	-0.7
847199	Automatic data processing machines and units, nes	0.3	1.4	0.2	0.9	-0.5

Top 10 Products in 2002 that turns Mutual Expansion by 2012						
		2002		2012		% Diff
Product Code	Products Description	US$ Bn	% of E&E	US$ Bn	% of E&E	
854140	Photosensitive semiconductor devices, photovoltaic	0.1	0.7	1.8	10.8	10.1
850910	Domestic vacuum cleaners	0.01	0.03	0.3	1.7	1.7
853710	Boards, panels, including numerical control pan	0.1	0.3	0.3	1.6	1.3
901819	Electro-diagnostic apparatus, nes	0.0	0.0	0.1	0.7	0.7
852691	Radio navigational aid apparatus	0.0	0.0	0.1	0.7	0.7
853669	Electrical plugs and sockets, for a voltage	0.0	0.1	0.1	0.6	0.5
853120	Indicator panels incorporating liquid crystal d	0.0	0.1	0.1	0.5	0.4
852990	Parts for radio/tv transmit/receive equipment, nes	0.2	0.8	0.2	1.1	0.4
851650	Microwave ovens	0.1	0.5	0.1	0.8	0.3
847050	Cash registers	0.01	0.1	0.1	0.3	0.3

Products in 2002 that turns Reverse Competitive by 2012						
		2002		2012		% Diff
Product Code	Products Description	US$ Bn	% of E&E	US$ Bn	% of E&E	
852610	Radar apparatus	0.00	0.00	0.01	0.05	0.05
854030	Cathode-ray tubes	0.00	0.00	0.01	0.03	0.03
846921	Typewriters, electric, weighing not >1	0.00	0.00	0.00	0.03	0.03
850134	DC motors, DC generators, of an output >375 kW	0.00	0.00	0.00	0.00	0.00
900630	Cameras designed for special use, underwater, a	0.00	0.00	0.00	0.00	0.00
852190	Video recording or reproducing apparatus nes	0.26	1.33	0.21	1.27	-0.06

Source: Own calculations based on UNComtrade

Appendix 6.2 Top Malaysian E&E Products in Competitive, Mutual Expansion and Reverse Competitive Relationship with Chinese E&E Exports by 2012 for EU Market

Top 10 Products in 2002 that turns Competitive by 2012

Product Code	Products Description	2002		2012		% Diff
		US$ Bn	% of E&E	US$ Bn	% of E&E	
847192	Input or output units, whether or not presented	0.8	7.9	0.4	2.7	-0.1
851740	Apparatus, for carrier-current line systems, nes	0.2	2.2	0.0	0.0	0.0
852520	Transmit-receive apparatus for radio, TV, etc.	0.4	3.5	0.3	1.9	0.0
852110	Video recording or reproducing apparatus magnet	0.3	2.7	0.2	1.4	0.0
854110	Diodes, other than photosensitive or light emit	0.2	1.6	0.1	0.7	0.0
851999	Sound reproducing apparatus, not incorporating	0.1	1.0	0.1	0.4	0.0
841581	Air conditioning equipment, machinery	0.1	0.8	0.0	0.2	0.0
852290	Parts and accessories of apparatus of heading	0.1	0.7	0.0	0.1	0.0
852810	Colour television receivers/monitors/projectors	0.1	1.1	0.1	0.6	0.0
852739	Radio-broadcast receivers nes	0.1	0.8	0.0	0.3	0.0

Top 10 Products in 2002 that turns Mutual Expansion by 2012						
		2002		2012		
Product Code	Products Description	US$ Bn	% of E&E	US$ Bn	% of E&E	% Diff
851783	Telegraphic apparatus, nes	0.1	1.1	2.3	16.6	15.5
847330	Parts and accessories of automatic data process	1.0	10.2	2.3	16.5	6.3
850910	Domestic vacuum cleaners	0.1	0.6	0.3	2.0	1.4
853710	Boards, panels, including numerical control pan	0.0	0.2	0.2	1.4	1.2
854129	Transistors, except photosensitive, > 1 watt	0.1	0.9	0.3	2.0	1.1
850880	Tools, hand-held, with electric motor, not drills/saw	0.0	0.1	0.1	1.0	0.9
841590	Parts of air conditioning mach.	0.0	0.0	0.1	0.7	0.7
851790	Parts of line telephone/telegraph equipment, nes	0.1	0.9	0.2	1.5	0.6
847120	Digital computers with cpu and input-output units	0.0	0.1	0.1	0.7	0.6
852691	Radio navigational aid apparatus	0.0	0.0	0.1	0.4	0.4

Products in 2002 that turns Reverse Competitive by 2012						
		2002		2012		
Product Code	Products Description	US$ Bn	% of E&E	US$ Bn	% of E&E	% Diff
841451	Fans: table, roof etc. with a self-contained electric motor	0.0	0.0	0.01	0.1	0.0
850790	Parts of electric accumulators, including separators	0.0	0.0	0.00	0.0	0.0
854419	Insulated (including enamelled or anodised) win	0.0	0.0	0.00	0.0	0.0
850422	Liquid dielectric transformers 650-10,000KVA	0.0	0.0	0.00	0.0	0.0
854099	Parts of valve and tubes, nes	0.0	0.0	0.00	0.0	0.0
841829	Refrigerators, household type	0.0	0.0	0.00	0.0	0.0
853661	Electrical lamp-holders, for < 1,000 volts	0.0	0.0	0.00	0.0	0.0

Note: Manual Adjustment, HS 854211 move to Mutual Expansion and combined with HS 854219. HS 851730 combined with HS 851782 to become HS 851783.

Source: Own calculations based on UNComtrade

Appendix 6.3 Distribution of Competitive Analysis Outcomes in 2012 to 2002 according to E&E Product Codes (EU Market)

Results 2002	No. of Prod	USD Bn	% of E&E	Results 2012	No. of Prod	USD Bn	% of E&E
Competitive	21	0.4	4.0	Competitive	122	2.9	20.7
M. Expansion	99	3.1	31.1				
M. Withd.	2	0.1	1.1				
Total	122	3.7	36.2				
Competitive	27	0.1	1.4	M. Expansion	131	10.9	78.1
M. Expansion	93	5.3	52.4				
M. Withd.	1	0.0	0.0				
N.A.	10	0.0	0.0				
Total	131	5.4	53.8				
Competitive	3	0.0	0.0	R.Competition	7	0.0	0.1
M. Expansion	3	0.0	0.0				
N.A.	1	0.0	0.0				
Total	7	0.0	0.0				
Competitive	11	0.1	0.9	M. Withd.	51	0.2	1.2
M. Expansion	39	0.9	9.1				
R.Competition	1	0.0	0.0				
Total	51	1.0	10.0				
Competitive	3	0.0	0.0	N.A.	25	0.0	0.0
M.Withd.	2	0.0	0.0				
N.A.	20	0.0	0.0				
Total	25	0.0	0.0				
Grand Total	336	10.1	100.0	Grand Total	336	14.0	100.0

Note: M.Expansion = Mutual Expansion, R. Competition= Reverse Competition and M. Withd.=Mutual Withdrawal
Source: Own calculations based on UNComtrade

Appendix 6.4 Top Malaysian E&E Products in Competitive, Mutual Expansion and Reverse Competitive Relationship with Chinese E&E Exports by 2012 for Japan Market

Top 10 Products in 2002 that turns Competitive by 2012

Product Code	Products Description	2002		2012		% Diff
		US$ Bn	% of E&E	US$ Bn	% of E&E	
Combine 854211+ 854219*	Monolithic integrated circuits, digital & Non-Digital	1.0	22.0	0.68	12.6	-9.5
847191	Digital process units whether or not presented	0.2	3.8	0.01	0.2	-3.6
847330	Parts and accessories of automatic data process	0.3	5.5	0.11	2.1	-3.4
852731	Radio broad receiver combined with sound record/reproducing	0.2	4.1	0.04	0.7	-3.4
847199	Automatic data processing machines and units, nes	0.1	3.1	0.01	0.2	-2.8
851999	Sound reproducing apparatus, not incorporating	0.1	2.7	0.01	0.1	-2.6
852110	Video recording or reproducing apparatus magnet	0.2	4.5	0.12	2.2	-2.3
847193	Computer data storage units	0.3	5.8	0.24	4.3	-1.5
900691	Parts and accessories for photographic cameras	0.1	1.4	0	0.0	-1.4
854380	Electrical machines and apparatus, nes	0.1	2.3	0.06	1.1	-1.2

Top 10 Products in 2002 that turns Mutual Expansion by 2012						
Product	Products Description	2002		2012		% Diff
		US$ Bn	2002 % of E&E	US$ Bn	% of E&E	
851783	Combined telegraph apparatus and nes	0.05	1.0	0.67	12.4	11.3
850440	Static converters, nes	0.05	1.0	0.13	2.4	1.4
847290	Office machines, nes	0.01	0.3	0.07	1.3	1.0
854160	Mounted piezo-electric crystals	0.04	0.8	0.09	1.7	1.0
850980	Domestic appliances, with electric motor, nes	0.00	0.0	0.05	0.9	0.9
854129	Transistors, other than photosensitive transistor	0.02	0.4	0.07	1.3	0.9
853690	Electrical switch, protector, connecter < 1kV	0.03	0.7	0.09	1.6	0.9
851629	Electric space heating apparatus and electric s	0.02	0.5	0.07	1.3	0.8
841451	Fans: table, roof etc. with a self-contain electric mtr	0.01	0.2	0.05	0.9	0.7
903020	Cathode-ray oscilloscopes, oscillographs	0.01	0.2	0.03	0.6	0.5

Products in 2002 that turns Reverse Competitive by 2012						
Product Code	Products Description	2002		2012		% Diff
		US$ Bn	% of E&E	US$ Bn	% of E&E	
850910	Domestic vacuum cleaners	0.00	0.1	0.2	3.68	3.58
852711	Radio receivers, portable, with sound reproduce/ rec	0.03	0.75	0.16	2.91	2.16
850511	Permanent magnets and art. intended to become p	0.00	0.1	0.06	1.02	0.92
853225	Electrical capacitors, fixed,	0.00	0.02	0.01	0.18	0.16
854511	Carbon or graphite electr	0.00	0.0	0.0	0.02	0.02
853649	Electrical relays for a voltage exceed 60 V but	0.00	0.0	0.0	0.02	0.02
852610	Radar apparatus	0.00	0.0	0.0	0.0	0.0
854330	App. for electro-plating.	0.00	0.0	0.0	0.0	0.0
847230	Machinery for mail proc.	0.00	0.0	0.0	0.0	0.0
851130	Distributors& ignition coils	0.00	0.0	0.0	0.0	0.0

Note: Manual Adjustment, HS 854211 move to Mutual Expansion and combined with HS 854219. HS 851730 combined with HS 851782 to become HS 851783.

Source: Own calculations based on UNComtrade

Appendix 7.1 List of Products in HS Codes

HS Code	Description
842119	Centrifuges, incl. centrifugal dryers, other than cream separators & clothes-dryers
842489	Mechanical appls. (excl. of 8424.10-8424.30), whether or not hand-operated, for projecting/dispersing/spraying liquids/powders other than agricultural/horticultural
845610	Operated by laser or other light or photon beam processes
845691	Machine-tools for working any mat. by removal of mat., by electro-chemical/electron beam/ionic-beam/plasma arc processes, for dry-etching patterns on semiconductor mats.
845699	Machine-tools for working any mat. by removal of mat., by electro-chemical/electron beam/ionic-beam/plasma arc processes, n.e.s. in 84.56
846221	Numerically controlled
846229	Bending/folding/straightening/flattening machines (incl. presses) for working metal other than numerically controlled
846420	Grinding or polishing machines
846490	Machine-tools for working stone/ceramics/concrete/asbestos-cement/like min. mats./for cold working glass (excl. of 8464.10 & 8464.20)
846599	Machine-tools (incl. machines for nailing/stapling/glueing/othw. assembling) for working wood/cork/bone/hard rubber/hard plastics/sim. hard mats., n.e.s. in 84.65
846610	Tool holders and self-opening die heads
846620	Work holders
846630	Dividing heads and other special attachments for machine tools
846693	For machines of headings 84.56 to 84.61
846694	For machines of heading 84.62 or 84.63
847710	Injection moulding machines
847740	Vacuum moulding machines and other thermoforming machines
847759	Machinery for moulding/othw. forming rubber/plastics (excl. of 8477.51)

HS Code	Description
847790	Marts for the machines of 84.77
847989	Machines & mech. appls. having individual functions, n.e.s./incl. in Ch.84
848071	Injection or compression types
851430	Other furnaces and ovens
851590	Parts of the machines & app. of 85.15
854311	Ion implanters for doping semiconductor mats.
854389	Other electrical machines & app., having individual functions, n.e.s. in Ch.85
854390	Parts of the mach. & app. of 85.43
901041	Direct write-on-wafer app. for the projection/drawing of circuit patterns on sensitised semiconductor mats.
901042	Step & repeat aligners for the projection/drawing of circuit patterns on sensitised semiconductor mats.
901049	Apparatus for the projection/drawing of circuit patterns on sensitised semiconductor mats. (excl. of 9010.41 & 9010.42)
901090	Parts & accessories of the app. of 90.10
903082	For measuring or checking semiconductor wafers or devices
903090	Parts & accessories of the instr. & app. of 90.30
903141	Optical instr. & appls. for inspecting semiconductor wafers/devices/for inspecting photomasks/reticles used in manufacturing semiconductor devices
903149	Optical meas./checking instr. & appls., n.e.s. in Ch.90
903180	Measuring/checking instr., app.& machines, n.e.s. in Ch. 90
903190	Parts & accessories of the instr., app. & machines of 90.31

Source: UNComtrade

Appendix 7.2 Integrated Circuits SEM Value Chain with Corresponding HS Codes of Machinery Used in Production

Stages of Production	HS Codes Rev. 2002	HS Code Description
Silicon wafer	846420	Grinding or polishing machines
	847989*	Machines For Manufacture Of Boules Or Wafers (HS 848610 in HS 2007)
Wafer Processing	842119	Centrifuges, incl. centrifugal dryers, other than cream separators & clothes-dryers
	842489	Mechanical appls. (excl. of 8424.10-8424.30), whether or not hand-operated, for projecting/dispersing/spraying liquids/powders other than agricultural/horticultural
	845610	Operated by laser or other light or photon beam processes
	845691	Machine-tools for working any mat. by removal of mat., by electro-chemical/electron beam/ionic-beam/plasma arc processes, for dry-etching patterns on semiconductor mats.
	845699	Machine-tools for working any mat. by removal of mat., by electro-chemical/electron beam/ionic-beam/plasma arc processes, n.e.s. in 84.56
	846221	Bending/folding/straightening/flattening machines (incl. presses) for working metal, numerically controlled
	846229	Bending/folding/straightening/flattening machines (incl. presses) for working metal other than numerically controlled
	846490	Machine-tools for working stone/ceramics/concrete/asbestos-cement/like min. mats./for cold working glass (excl. of 8464.10 & 8464.20)
	846599	Machine-tools (incl. machines for nailing/stapling/glueing/othw. assembling) for working wood/cork/bone/hard rubber/hard plastics/sim. hard mats., n.e.s. in 84.65
	846610	Tool holders and selfopening dieheads
	846620	Work holders
	846630	Dividing heads and other special attachments for machinetools

Stages of Production	HS Codes Rev. 2002	HS Code Description
	846693	For machines of headings 84.56 to 84.61
	846694	For machines of heading 84.62 or 84.63
	851430	Other furnaces and ovens
	854311	Ion implanters for doping semiconductor mats.
	854389	Other electrical machines & app., having individual functions, n.e.s. in Ch.85 (contains HS 848620 Machines For The Manufacture Of Semiconductors Or ICs)
	854390	Parts of the mach. & app. of 85.43
	901041**	Direct write-on-wafer app. for the projection/drawing of circuit patterns on sensitised semiconductor mats.
	901042	Step & repeat aligners for the projection/drawing of circuit patterns on sensitised semiconductor mats.
	901049	Apparatus for the projection/drawing of circuit patterns on sensitised semiconductor mats. (excl. of 9010.41 & 9010.42)
	901090	Parts & accessories of the app. of 90.10
	903082**	Instruments & apparatus for measuring or checking semiconductor wafers or devices
	903090	Parts & accessories of the instr. & app. of 90.30
Wafer Test	903141**	Optical instr. & appls. for inspecting semiconductor wafers/devices/for inspecting photomasks/reticles used in manufacturing semiconductor devices (excl. of 9030.82)
	847710	Injection moulding machines
	847740	Vacuum moulding machines and other thermoforming machines
Assembly (Chip Packaging)	847759	Machinery for moulding/othw. forming rubber/plastics (excl. of 8477.51)
	847790	Marts for the machines of 84.77 (contains 848690 Parts Of Machines Used In Manufacturing Of Semiconductors, FPD)
	847989	Machines & mech. appls. having individual functions, n.e.s./incl. in Ch.84
	848071	Injection or compression types
	851590	Parts of the machines & app. of 85.15
	903082**	Instruments & apparatus for measuring/checking semiconductor wafers/devices

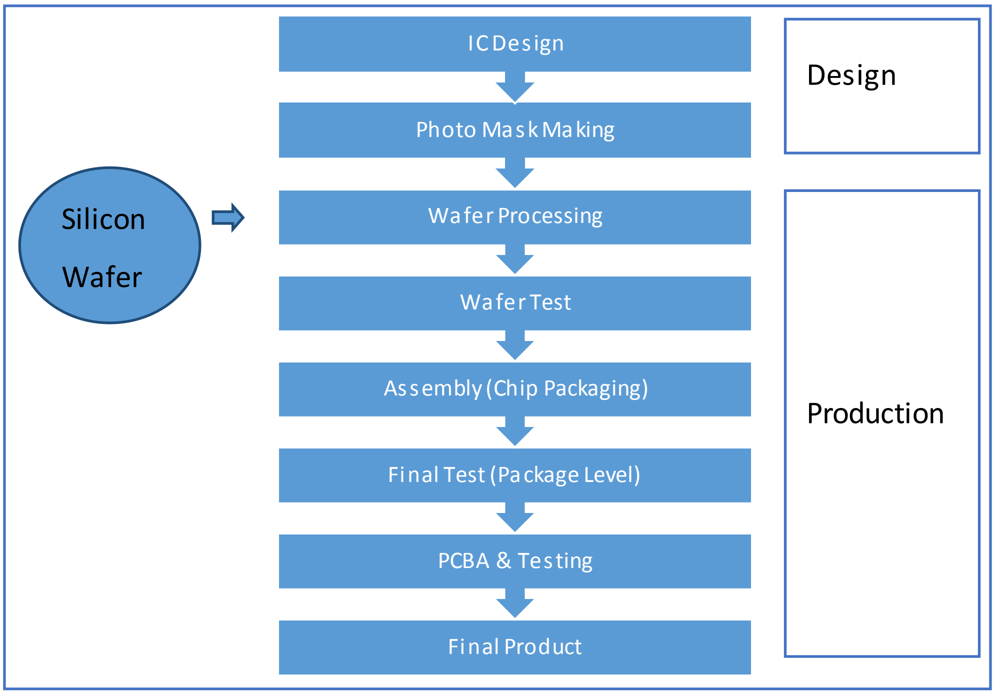
Stages of Production	HS Codes Rev. 2002	HS Code Description
	903141**	Optical instr. & appliances for inspecting semiconductor wafers/devices/for inspecting photomasks/reticles used in manufacturing semiconductor devices (excl. of 9030.82)
Final Test (Package Level)	903149	Optical meas./checking instr. & appls., n.e.s. in Ch.90
	903180	Measuring/checking instr., app.& machines, n.e.s. in Ch. 90
	903190	Parts & accessories of the instr., app. & machines of 90.31

Note:

1) Items marked * are items, which are traced backwards using HS 2007 Nomenclature to HS 2002 Nomenclature concordance table for semiconductor machine items.
2) Items marked ** are duplicates and can be used in Wafer test processing stage and wafer testing stage. The above table is general guide of machines used in the different stages of production of ICs. Machines like *Direct write-on-wafer app. for the projection/drawing of circuit patterns on sensitised semiconductor mats.* (HS 901041) though listed in Wafer Processing stage, can be used in Wafer Test stage, to repair the silicon circuit diagram.

Source: Own Elaboration based on IC Supply Chain diagram
from Silterra Malaysia and Sykes and Yinug (2006)

Appendix 7.3 Detail Steps of IC Production



Source: Adopted from Silterra Corporation Malaysia

Available at: http://www.silterra.com/supply_chain.html

Fabrication of the semiconductor industry is referred as the front-end of the industry and this includes the wafer processing and wafer test. Fabrication of the silicon wafer is a combination of physics and chemistry processes. The production process starts with the deposit of a material, usually it is silicon oxide on silicon wafers. A silicon wafer has multiple layers of photomask being printed on it. In between the printing of the silicon mask, which essential forms the circuit diagram of the IC, the fabrication process also deposits chemicals and implant ions into the silicon wafer. After that, the machines remove any excess chemical from the silicon wafer after each print. This process of printing of the silicon wafer is called photo-masking. Depending on the literature, the process of photo-masking is also referred as photolithography.

Due to advancement of technology, printing of the circuits is done at extremely fine level and layers of printing are done repeatedly based on the IC design. To give an idea of how fine this process is, the nodes or the length between 'the physical gates' inside the semiconductor is currently at around 30 nanometres, (Pangrle, 2014) and a human hair diameter ranges from 58 to 100 microns) (Lo'real, (n.d)). [137]Generally, the smaller the nodes size, it means more transistors can be fitted into the IC within the same surface area and therefore, it translate into a higher computing power. [138] As the fabrication of IC on silicon wafers are done at a very fine level, this production stage takes place in a clean room, with the air in the production room being regularly filtered at extremely fine level to remove any particles that can potentially disrupt the fabrication process. Access to the clean room requires workers to don the 'bunny' suits as seen in the Intel advertisement in the 1990s.

Once the wafer is fabricated, it is tested with the use of customised probing machines to weed out defective wafers. The added thickness of the fabricated wafers is hardly noticeable by the naked eye, but the circuits embedded on the wafer are visible if lights are shone on the wafer.

After that, the fabricated wafers are shipped to another location and from this point forward, the process is referred by the IC industry as the back-end process. The fabricated wafers are ground to make them thinner and then sawed into individual units (referred as die from this point forward). The die are then glued to its packaging using special formulated liquids, then gold wires are soldered to the lead frames to connect the silicon chip

[137] 1 nanometres =0.001 microns

[138] Technical understanding of semiconductor can be complex. A CEO of a semiconductor company explains for beginners, silicon IC fabrication is drawn to its similarities with a building a tall multi-storey building. In fabrication of the IC, layers or the number of floors are being added to the 'building', with each floor, having a specific function for the whole building, such as controlling and monitoring power for the IC chips, some floors are specifically build to process certain signals, etc.

with the packaging. IC Packaging comes in different forms and sizes but the typical ones are made of plastics, metal or glass with pins protruding. These pins make the connection from the silicon part of the IC with other electrical devices.[139] Next, the chips are moulded using a mould injection technique where advanced material are melted and then cured to form the encapsulation of the IC. The encapsulated ICs are then marked with lasers with information of the batch no. and trademarks. In the final stage of the production, the IC chips are checked and tested to see if they are functioning as intended. The IC chips that pass the tests are now ready for shipment either in the form of tape or tray.

[139] Depending on type of packaging, for Ball Grid Arrays (BGA), the metal balls are positioned into tiny holes between the board and the IC package, and then electrical connects are made when the metal balls are melted onto the electrical board.

Appendix 7.4 Share of Testing Machines to Total Semiconductor Manufacturing Equipment (Malaysia as Reporter)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average (2002-2013)
% of testing to SME Export to China	38.20%	38.68%	68.70%	51.31%	77.97%	45.10%	63.34%	45.68%	71.23%	64.89%	69.88%	60.38%	57.95%
% of testing products to SME Total Export (World)	48.77%	50.00%	45.94%	44.88%	50.57%	43.79%	53.12%	45.29%	59.40%	55.57%	66.07%	56.59%	51.67%

Note: HS code 903082, 903090, 903141, 903149, 903180, 903190 are semiconductor testing equipment.

Source: Own calculations based on UNComtrade

Appendix 7.5 Balance of Trade for Semiconductor Manufacturing Equipment Malaysia and China

HS Code	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
842119	- 0.00	0.01	0.00	0.00	-0.00	- 0.00	- 0.03	0.01	- 0.02	- 0.01	- 0.03	- 0.04
842489	0.00	- 0.00	- 0.02	- 0.01	-0.05	- 0.06	- 0.11	- 0.13	- 0.12	- 0.15	- 0.22	- 0.05
845610	0.00	- 0.00	- 0.00	- 0.00	-0.02	- 0.01	- 0.01	- 0.01	- 0.02	- 0.01	- 0.02	- 0.12
845691	-	0.00	-	0.00	-0.01	- 0.00	- 0.00	-	-	-	-	-
845699	0.00	0.07	0.00	- 0.00	-0.01	0.00	0.01	0.00	- 0.00	0.00	- 0.01	- 0.01
846221	- 0.00	0.00	- 0.00	- 0.00	-0.01	- 0.01	- 0.00	- 0.01	- 0.00	- 0.02	- 0.01	- 0.01
846229	- 0.01	0.02	- 0.01	0.14	-0.03	- 0.04	- 0.04	- 0.04	- 0.45	- 0.11	- 0.29	- 0.10
846420	- 0.00	- 0.00	- 0.00	- 0.02	-0.01	- 0.02	- 0.02	- 0.02	- 0.01	- 0.03	- 0.01	- 0.02
846490	- 0.00	- 0.00	- 0.00	- 0.02	-0.03	- 0.03	- 0.04	- 0.04	- 0.06	- 0.04	- 0.03	- 0.04
846599	- 0.03	0.05	- 0.04	- 0.10	-0.18	- 0.12	- 0.07	- 0.07	- 0.11	- 0.14	- 0.13	- 0.07
846610	- 0.00	- 0.00	- 0.00	- 0.00	-0.00	- 0.00	0.02	- 0.00	- 0.00	- 0.01	- 0.02	- 0.04
846620	0.00	0.00	- 0.00	- 0.00	-0.01	0.00	- 0.01	- 0.00	0.00	- 0.00	- 0.08	- 0.06
846630	- 0.01	- 0.00	- 0.00	0.00	0.00	- 0.00	- 0.00	0.02	- 0.00	- 0.00	- 0.00	- 0.00
846693	0.00	0.00	- 0.03	0.01	0.01	- 0.01	- 0.01	0.01	0.03	- 0.02	- 0.04	0.00
846694	0.02	0.00	- 0.01	- 0.00	0.03	0.04	0.03	0.01	0.08	0.06	- 0.10	- 0.00
847710	- 0.01	- 0.04	- 0.11	- 0.15	-0.12	- 0.19	- 0.16	- 0.17	- 0.32	- 0.41	- 0.32	- 0.33

HS Code	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
847740	0.00	0.00	0.01	- 0.00	-0.01	- 0.01	0.01	- 0.00	- 0.01	- 0.02	- 0.01	- 0.03
847759	0.00	0.01	- 0.01	- 0.02	-0.03	- 0.02	- 0.03	- 0.03	- 0.04	- 0.03	- 0.03	- 0.01
847790	- 0.00	0.01	- 0.04	- 0.03	-0.05	- 0.06	- 0.01	0.00	- 0.08	- 0.08	- 0.08	- 0.14
847989	0.11	0.08	- 0.02	- 0.13	-0.12	0.16	- 0.13	0.04	- 0.06	- 1.44	- 0.24	- 0.49
848071	- 0.01	- 0.04	- 0.02	- 0.03	-0.18	- 0.19	- 0.13	- 0.09	- 0.06	- 0.13	- 0.18	- 0.20
851430	0.02	0.00	- 0.01	- 0.02	-0.03	- 0.04	- 0.18	- 1.12	- 0.29	- 0.22	- 2.50	- 0.47
851590	- 0.01	- 0.00	- 0.02	- 0.01	-0.03	- 0.03	- 0.04	- 0.04	- 0.04	- 0.08	- 0.08	- 0.06
854311	-	-	-	-	-0.00	- 0.00	- 0.00	-	-	-	-	-
854389	- 0.03	- 0.01	- 0.04	0.23	-0.07	- 0.03	- 0.05	- 0.10	- 0.13	- 0.13	- 0.05	- 0.19
854390	- 0.01	- 0.03	- 0.04	- 0.03	0.00	0.02	- 0.04	- 0.03	- 0.08	- 0.15	- 0.17	- 0.09
901041	-	-	-	-	-	-	-	-	-	-	-	-
901042	-	-	-	-	-	-	-	-	-	-	-	-
901049	-	0.06	-	-	-0.00	- 0.00	-	-	-	-	-	-
901090	- 0.00	- 0.01	0.00	- 0.00	-0.00	- 0.00	- 0.00	- 0.00	- 0.00	- 0.05	- 0.00	- 0.00
903082	0.01	0.01	- 0.05	0.04	-0.05	0.03	- 0.01	0.02	- 0.23	0.08	0.35	0.11
903090	0.03	- 0.13	- 0.12	- 0.21	-0.17	- 0.17	- 0.09	- 0.07	0.49	0.32	0.76	0.37
903141	0.03	- 0.00	0.03	0.00	-0.08	- 0.02	0.05	0.02	0.13	0.12	0.10	0.06

HS Code	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
903149	0.01	0.00	0.01	- 0.02	-0.26	- 0.19	0.00	- 0.03	0.05	0.01	- 0.01	0.06
903180	0.02	0.03	0.08	0.13	-0.12	- 0.01	- 0.16	0.01	0.27	0.23	0.07	- 0.20
903190	0.00	0.09	0.02	0.03	0.81	- 0.09	0.17	- 0.19	0.89	0.06	- 0.30	- 0.12
Balance	0.13	0.17	- 0.45	- 0.24	-0.81	- 1.12	- 1.06	- 2.04	- 0.19	- 2.41	- 3.67	- 2.29

Source: Own calculations based on UNComtrade

Appendix 7.6 Revealed Comparative Advantage for Semiconductor Manufacturing Equipment (Malaysia)

HS Code	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
842119	0.2	0.3	0.1	0.0	0.1	0.1	0.2	0.4	0.2	0.3	0.3
842489	0.3	0.2	0.2	0.3	0.3	0.6	0.6	0.3	0.3	0.5	0.8
845610	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0
845691	0.0	0.0	0.0	0.0	0.0	62.9	67.2	0.0	0.0	0.0	0.0
845699	2.8	2.2	1.4	0.3	0.3	0.5	0.3	0.6	1.0	0.8	0.7
846221	0.0	0.0	0.1	0.2	0.1	0.3	0.1	0.0	0.0	0.0	0.0
846229	0.3	0.5	0.4	1.9	0.7	0.5	0.4	0.4	0.5	0.3	0.3
846420	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.1
846490	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.4	0.9	0.1
846599	0.6	1.3	0.9	0.9	0.9	0.6	0.5	0.5	1.3	1.0	0.3
846610	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.5	0.3	0.2	0.4
846620	0.3	0.2	0.1	0.1	0.2	0.3	0.1	0.2	0.1	0.2	0.4
846630	0.4	0.2	0.2	0.2	0.4	0.2	0.2	0.6	0.2	0.4	1.2
846693	0.3	0.2	0.2	0.3	0.4	0.5	0.8	1.0	0.9	0.6	0.5
846694	0.3	0.3	0.3	0.3	0.8	0.9	0.9	0.7	1.3	1.6	0.6
847710	0.3	0.2	0.2	0.2	0.2	0.2	0.4	0.6	0.6	0.3	0.5
847740	0.3	0.2	0.2	0.1	0.1	0.2	0.4	0.3	0.3	0.2	0.5
847759	0.2	0.6	0.3	0.4	0.6	0.3	0.5	0.1	0.6	0.5	0.4
847790	0.3	0.3	0.5	0.7	0.6	0.6	0.6	0.9	0.9	0.5	0.5
847989	0.4	0.4	0.3	0.3	0.3	0.2	0.3	0.4	0.3	0.3	0.8
848071	0.3	0.2	0.2	0.3	0.3	0.4	0.3	0.2	0.2	0.3	0.2
851430	0.4	0.6	0.2	0.2	0.3	0.3	0.3	0.3	1.2	0.9	1.2
851590	0.4	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.7	0.5	0.2
854311	0.0	0.0	0.0	0.0	0.0	32.5	0.0	0.0	0.0	0.0	0.0
854389	0.1	0.2	0.6	1.1	0.7	1.3	0.1	0.7	0.6	0.8	0.9
854390	0.4	0.3	0.3	0.8	0.7	0.8	0.6	0.4	0.5	1.3	1.5
901041	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
901042	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
901049	0.2	0.4	0.0	0.0	0.0	45.4	8.2	0.0	0.0	0.0	0.0
901090	0.1	0.1	1.0	0.8	0.1	1.8	1.7	0.9	1.8	2.2	2.3
903082	0.6	1.2	0.5	0.5	0.9	0.6	2.8	3.0	4.3	6.2	17.0
903090	1.9	2.8	3.4	4.1	4.5	5.2	6.1	6.1	9.9	9.6	17.4
903141	0.2	0.5	0.2	0.1	0.3	0.2	1.3	1.0	1.0	1.7	1.0
903149	0.3	0.4	0.2	0.4	0.4	0.6	0.6	0.6	0.4	0.2	0.1
903180	0.5	0.5	0.7	0.3	0.3	0.3	0.5	0.6	0.9	0.8	0.6
903190	2.6	2.2	1.7	3.8	4.1	2.7	2.2	1.5	3.5	2.3	4.1

Note: Numbers shaded are RCA>1
Source: Own calculations based on UNComtrade

Appendix 7.7 Share of Exports by Trading Partners for Optical instruments. & appliances. for inspecting semiconductor wafers/devices/for inspecting photomasks/reticles used in manufacturing semiconductor devices (HS Code 903141)

	%							
Country	2002	2003	2004	2005	2006	2007	2008	2009
China	63.6	6.6	46.6	30.4	0.1	6.4	32.9	30.6
USA	6.1	2.8	4.9	7.7	10.4	37.5	24.1	10.3
Singapore	10.6	30.2	37.1	39.9	6.9	18.0	15.6	31.2
Other Asia	2.6	17.5	0.3	4.1	44.4	2.2	9.1	0.7
Mexico	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0
Hong Kong	0.0	0.5	3.0	4.2	9.4	8.6	1.3	0.0
Thailand	0.0	1.4	0.4	0.0	0.3	4.8	1.4	6.8
Philippines	0.2	0.0	0.0	2.1	0.4	6.4	2.6	1.3
S. Korea	2.2	0.4	0.1	1.3	20.1	0.9	2.0	14.5
Japan	10.0	35.5	2.5	1.6	0.8	0.4	0.7	3.6
Others	4.6	5.2	5.2	8.8	7.2	14.8	9.5	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Country	2010	2011	2012	2013
China	47.7	19.8	29.8	33.0
USA	4.0	46.4	23.7	14.0
Singapore	22.2	9.9	9.3	9.3
Other Asia	4.0	11.5	15.7	15.6
Mexico	2.4	1.6	0.4	8.9
Hong Kong	8.9	2.6	3.0	6.5
Thailand	8.6	2.0	0.5	2.3
Philippines	0.2	0.5	7.1	5.7
S. Korea	0.5	1.9	3.2	0.8
Japan	0.5	0.7	2.4	0.1
Others	1.0	3.2	5.0	4.0
Total	100.0	100.0	100.0	100.0

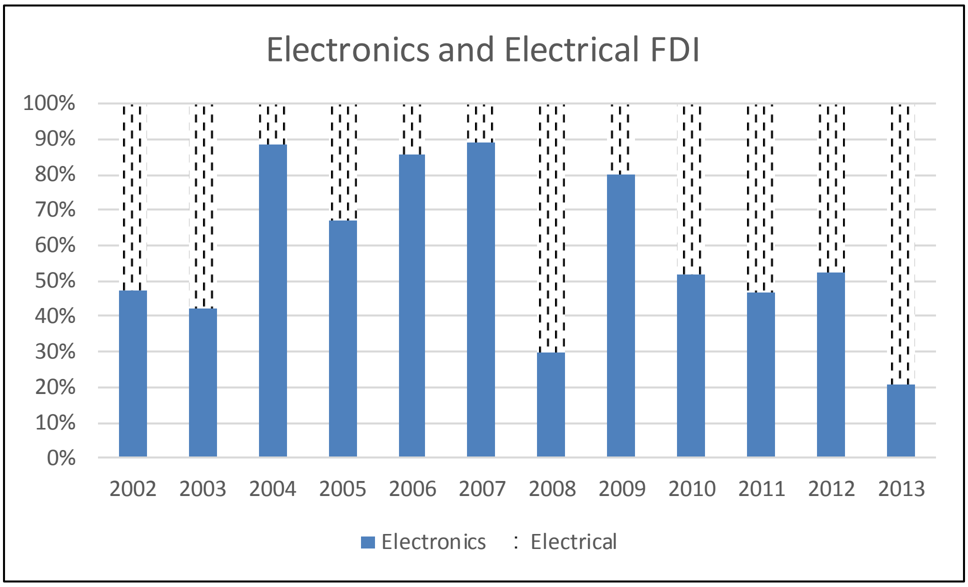
Source: Own calculations based on UNComtrade

Appendix 7.8 Annual Silicon Shipment Statistics from SEMI (Global Association for Silicon-based products shipment)

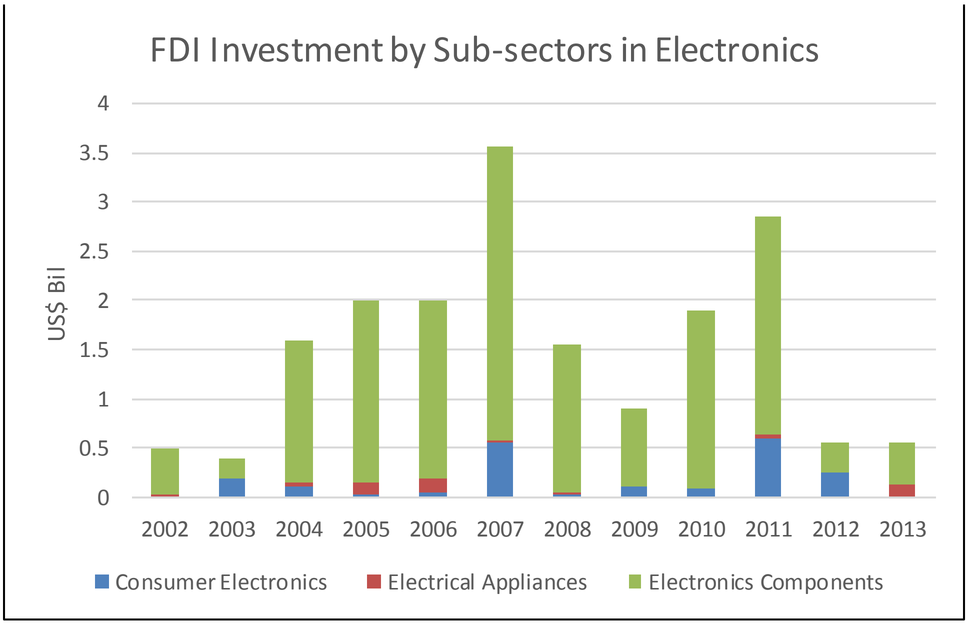
Worldwide Silicon Data	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Area Shipments (MSI)	6,645	7,996	8,661	8,137	6,707	9,370
Revenues ($B)	7.9	10.0	12.1	11.4	6.7	9.7

*Shipments are for semiconductor applications only and do not include solar applications
Source: SEMI® (2011)

Appendix 8.1 FDI for E&E sector by Sub-sector



Source: MIDA



Source: MIDA

Appendix 8.2 Investment inflow and outflow to Malaysia, China as Reporter

Inflows						(US$ Millions)						
Region / economy	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Malaysia	263	368	251	385	361	393	397	247	429	..	358	..
Outflows						(US$ Millions)						
Region / economy	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Malaysia	..	..	1.97	8.12	56.72	7.51	-32.82	34.43	53.78	163.54	95.13	199.04
Inflows/ Outflows	0	0	127	47	6	52	0*	7	8	0	4	0

* Adjusted due to negatives.

Note: Due to countries definition of what constitutes as FDI might differ between countries, for example, one country might treat reinvested earnings as FDI, but another might not, and different accounting practice across countries also has an effect on the FDI numbers in bilateral settings.
Source: UNCTAD WIR Website

Appendix 8.3 Rajah Rasiah's Taxonomy of Level of R&D

Level	Knowledge depth	Human Resources	Process	Product
1	Simple activities	On the job and in-house training	Dated machinery with simple inventory and control techniques	Assembly or processing of component, CKD and CBU using foreign technology
2	Minor Improvements	In-house training and performance rewards	Advanced machinery, layouts and problem solving	Precision engineering
3	Major Improvements	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 TQC) with OEM capability
4	Engineering	Hiring engineers for adaptation activities; separate training departments	Process adaptation: layouts, equipment and techniques	Product adaptation
5	Early R&D	Hiring engineers for product development activities, separate specialised training activities	Process development: layouts and machinery and equipment, materials and processes	Product development capability. Some firms take on ODM capability
6	Mature R&D	Hiring specialised 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

Note: CKD: Complete knock-down, CBU: Complete Built 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.

Source: Rasiah (2010)

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