ECO-INNOVATION IN THE CHEMICAL MANUFACTURING INDUSTRY: STATUS AND ITS DETERMINANTS

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ABSTRACT

Eco-innovation has emerged as an imperative technological paradigm for governments and firms seeking to promote sustainable manufacturing practices propelling towards the green growth path. This study aims to identify the state of eco-innovation of the chemical industries. The study further develops a holistic eco-innovation framework and empirically examines the determinants of eco-innovation in the Malaysian chemical-manufacturing firms. A sequential exploratory design was used for the purpose of this study. The qualitative analysis deploys a case study approach where semi-structured interviews with six chemical firms were conducted to gauge the state of eco-innovation practices and to validate the holistic eco-innovation framework, based especially on the nine eco-innovation drivers identified from the literature. Survey questionnaires were then distributed to the chemical firms located in the state of Selangor and the data was used to empirically examine the relationship between the eco-innovation drivers and eco-innovation. For this purpose, the Partial Least Square (PLS) technique was used. The results show that in terms of state of eco-innovation, firms are largely net adopters. However, the level of creation of eco-innovation taking place indicated that firms have embraced advanced sustainable manufacturing practices and concepts. Firms are moving away from eco-innovations that merely treat pollutants at the end of manufacturing process to eco-innovations that manage these pollutants at the initial stage of production. Credit for the success of eco-innovation and sustainable manufacturing practices that firms have achieved thus far is due to high top management commitment and strong corporate environmentalism culture. Meanwhile, the eco-innovations framework structured based on the interviews, exhibited a merger of three sub-models, namely; resources, strategy and eco-innovation models that link the eco-innovation drivers through direct and indirect linkages. Eco-innovation in the chemical firms was mainly driven by the firms' environmental strategies and

environmental regulations. Environmental strategies display a central tendency to connect with other eco-innovation drivers within the eco-innovation framework. Export behaviour and environmental collaboration, meanwhile exhibited strong indirect effect on eco-innovation through environmental strategies. The implications of the study are as follows. Although governmental actions through command and control policies have in the past promoted eco-innovation among firms, however, it was increasing demand for green products and emerging environmental issues that thrusted firms into their environmental strategies entailing for more flexible policy options such as informational measures, voluntary agreements and credible price signal. Firms also had an urgent need to strengthen their absorptive capacity due to huge amounts of practical and tacit knowledge involved during environmental strategy formulation but with no proper mechanism in place to capture this knowledge. On the theoretical front, the study confirms that the mix of theories and knowledge from the field of environmental economics, innovation economics and management are imperative to effectively develop a holistic eco-innovation framework and to provide practical solutions to problems related to eco-innovation. The study and its findings are still largely exploratory and sector specific, which limits generalization of the results. Therefore, a similar study in other manufacturing sectors is required to validate the eco-innovation framework and results.

ABSTRAK

Ekoinovasi muncul sebagai paradigma teknologi penting bagi kerajaan dan syarikat yang berusaha untuk menggalakkan amalan pembuatan lestari demi memacu ke arah pembangunan hijau. Kajian ini bertujuan untuk mengenal pasti keadaan ekoinovasi industri kimia. Selanjutnya, kajian ini membangunkan rangka kerja ekoinovasi holistik dan mengkaji secara empirik penentu ekoinovasi dalam syarikat kimia pembuatan Malaysia. Satu reka bentuk eksploratori berurutan digunakan untuk tujuan kajian ini. Analisis kualitatif menggunakan pendekatan kajian kes yang melibatkan temu bual separa berstruktur terhadap enam syarikat kimia dijalankan untuk mengukur keadaan amalan ekoinovasi dan untuk mengesahkan rangka kerja ekoinovasi holistik, terutamanya berdasarkan kepada sembilan pemacu ekoinovasi yang dikenal pasti daripada maklumat kepustakaan. Soal selidik tinjauan kemudiannya diedarkan kepada syarikat-syarikat kimia tersebut yang terletak di negeri Selangor dan data berkenaan digunakan untuk mengkaji hubungan antara pemacu ekoinovasi dan ekoinovasi secara empirik. Bagi tujuan ini, teknik Kuasa Dua Terkecil Separa (PLS) digunakan. Hasil kajian menunjukkan dari segi keadaan ekoinovasi, syarikat terbabit adalah penerima pakai utama. Walau bagaimanapun, tahap penciptaan ekoinovasi menunjukkan syarikat-syarikat terbabit telah menerapkan amalan dan konsep pembuatan lestari termaju. Syarikat-syarikat itu beralih daripada ekoinovasi yang hanya merawat bahan pencemar pada akhir proses pembuatan kepada ekoinovasi yang menguruskan bahan pencemar ini pada peringkat awal pengeluaran. Kredit untuk kejayaan ekoinovasi dan amalan pembuatan lestari yang dicapai oleh syarikat-syarikat tersebut setakat ini adalah kerana komitmen pengurusan atasan yang tinggi dan budaya persekitaran hidup korporat yang kukuh. Sementara itu, rangka kerja ekoinovasi berstruktur berdasarkan temu bual, menunjukkan penggabungan tiga sub-model, iaitu sumber, model strategi, dan ekoinovasi yang menghubungkan pemacu ekoinovasi melalui hubungan langsung dan

tidak langsung. Ekoinovasi dalam syarikat kimia dipacu terutamanya oleh strategi persekitaran dan peraturan persekitaran syarikat. Strategi persekitaran memaparkan kecenderungan memusat untuk menghubungkan pemacu-pemacu ekoinovasi lain dalam rangka kerja ekoinovasi tersebut. Sementara itu, tingkah laku eksport dan kerjasama persekitaran pula memperlihatkan kesan tidak langsung yang kukuh bagi ekoinovasi melalui strategi persekitaran. Implikasi kajian ini adalah seperti berikut. Walaupun tindakan kerajaan melalui dasar arahan dan kawalan pada masa lalu menggalakkan ekoinovasi dalam kalangan syarikat, namun permintaan untuk produk hijau dan isu-isu persekitaran baharu yang semakin meningkat melonjakkan syarikat ini kepada strategi persekitaran yang memerlukan lebih banyak pilihan dasar yang fleksibel seperti langkah-langkah bermaklumat, perjanjian sukarela, dan isyarat harga yang boleh dipercayai. Syarikat-syarikat ini juga mempunyai keperluan mendesak untuk mengukuhkan keupayaan penyerapan mereka kerana sejumlah besar pengetahuan praktikal dan tersirat terlibat semasa penggubalan strategi persekitaran, tetapi tiada mekanisme yang sesuai untuk menguasai pengetahuan ini. Berdasarkan teori, kajian ini mengesahkan bahawa gabungan teori dan pengetahuan daripada bidang ekonomi persekitaran, ekonomi inovasi, dan pengurusan adalah penting untuk membangunkan rangka kerja ekoinovasi holistik secara berkesan dan untuk menyediakan penyelesaian praktikal kepada masalah yang berkaitan dengan ekoinovasi. Kajian ini dan dapatannya masih sebahagian besarnya bersifat eksploratori dan untuk sektor tertentu, yang menghadkan generalisasi keputusan. Oleh itu, kajian yang sama dalam sektor pembuatan lain diperlukan untuk mengesahkan rangka kerja ekoinovasi dan keputusan tersebut.

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All errors and shortcomings remain my own.

Keshminder Singh Jit Singh
Selangor, Malaysia

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LIST OF ABBREVIATIONS

CAC	Command and control
CCPI	Climate Change Performance Index
CICM	Chemical Industries Council of Malaysia
DHQ	Domestic headquarters
DOE	Department of Environment
DOW	Domestic ownership
ED	Environmental Department
EE	Energy efficiency
EI	Eco-innovation
EO	Organizational eco-innovation
EP	Process eco-innovation
EPI	Environmental policy integration
EPR	Product eco-innovation
EPU	Economic Planning Unit
EQA	Environmental Quality Act
ERRI	Environmental regulatory regime index
FHQ	Foreign headquarters
FOW	Foreign ownership
GTMP	Green Technology Master Plan
IMP	Industrial Master Plan
ISB	Invest Selangor Berhad
KeTTHA	Ministry of Energy, Green Technology and Water
LERED	Lax environmental regulation export destination
LULUCF	Land use, land use change and forest
MATRADE	Malaysia External Trade Development Corporation
MBES	Mechanics Behind Environmental Strategy
MBI	Market based instrument
MIDA	Malaysian Investment Development Authority
MITI	Ministry of International Trade and Industry
MMD	Malaysian Meteorological Department
MNRE	Ministry of Natural Resource and Environment
MP	Malaysia Plan
MPC	Malaysia Productivity Corporation
OECD	Organization for Economic Co-operation and Development
PACE	Pollution abatement and control expenditure
RBV	Resource based view
RE	Renewable energy
SERED	Stringent environmental regulation export destination
SME	Small and medium enterprises
SOW	State ownership
SSM	Companies Commission of Malaysia

CHAPTER 1 : INTRODUCTION

1.1 Background

Manufacturing industries being the largest resource consumer worldwide (OECD, 2009a) is responsible for 38% of global carbon dioxide (CO^2) emission (IEA, 2008). The increasing manufacturing activities caused environmental problems related to climate change, increasing resource scarcity and energy security. Since then, the restructuring of environmental policies and firm practices designed to cope with this growing environmental problems received increasing attention from scholars of different disciplines and fields. Their pursue to solve this problem brought eco-innovation (EI) into attention as the solution to major environmental problems (Triguero, Moreno-Mondéjar, & Davia, 2013). EI refers to "the creation or implementation of new, or significantly improved products (goods and services), processes, marketing methods, organizational structures and institutional arrangements which - with or without intent – lead to environmental improvements compared to relevant alternatives" (OECD, 2009b, p. 2). EI has the ability to infuse eco-efficiency, which reduces the ecological impact of manufacturing activities.

Acknowledging the importance of EI to solve environmental problems, previous studies have profoundly contributed towards the extension of EI literature from quantitative and qualitative perspective. Large amount of studies have focused on two main areas of EI. First, exploring regulatory driven EIs (Jaffe & Palmer, 1997; Peters, Schneider, Griesshaber, & Hoffmann, 2012; Rennings & Rammer, 2011). Second, gauging firms internal and external EI determinants (Cuerva, Triguero-Cano, & Córcoles, 2014; del Río, 2009) and empirically quantifying them (Cai & Zhou, 2014; Horbach, 2008). Additionally, other studies have also tested the potential impact of EI towards firms growth and financial performance (Cheng, Yang, & Sheu, 2014; Doran & Ryan, 2014; Przychodzen & Przychodzen, 2015). Moreover, researcher have also experimented the contributions and interdependence of different types of EIs (i.e., process EI, product EI and organizational EI) (Demirel & Kesidou, 2011; Doran & Ryan, 2014; Horbach, Rammer, & Rennings, 2012).

Majority of these studies construed that EI determinants (i.e., regulatory push, demand-pull and supply push factors) play an imperative role, and claimed that a holistic eco-innovation model is required (Cheng et al., 2014) to implement effective EI policies/initiatives. This model has to be industry specific (Oltra, 2009) and exhibit strategic linkages between the EI determinants (del Río, Peñasco, & Romero-Jordán, 2016). This is because, environmental practices of firms vary across regions and industries due to different business culture between the regions and industry-specific challenges encountered (Fikru, 2014). Therefore, the understanding of environmental characteristics of the industry is imperative to capture the specific aspects of EIs, as EI depends on the relationship of an industry with the environment. Government and institutions have frequently placed greater emphasize on networks between firms to promote green industries, while networks within a firm requires more consideration when green industry projects are implemented (Williander, 2006). Prescription to environmental problems must be based on individual production intensity (Oltra, 2009). In order for manufacturing industries to scale up their EI, a detailed exploration of the industry level EI determinants, the relevant linkages and ways these determinants invigorate the existing capabilities is vital. The understanding of these mechanics is required to outline strategies that could bring together firm capabilities and resources to eco-innovate.

Besides reducing emissions, EI has the potential to catalyze green growth. With regard to economic growth, Schumpeter (1934) emphasized the gravity of innovation for growth. EI is a valuable component to reconstruct the innovation system within the new growth model, taking into account the green ecological perspective. EI has raised new opportunities by giving birth to new industries, jobs (Machiba, 2010), and better competitive position (Porter & Linde, 1995b). Firms are taking advantage of this transformation by adding value to business and creating own niche to remain competitive (Lozano, 2015). Additionally, through EI firms are also able to offset costs induced by environmental regulations.

From the discussion above, it is evident that benefits of EI are twofold; it reduces emissions and catalyzes green growth. However, to ensure effective emission reduction and sustained green growth, an industry driven holistic EI model is entailed. The EI model must explain the strategic linkages between the EI determinants for the best possible EI outcome. This model then could assist policy makers to implement strategies to cultivate EI by invigorating imperative EI determinants within the model. These strategies could replace the highly regulated driven policy mechanics to eco-innovate. This automatically provides greater liberty for the firms to eco-innovate and require less enforcement and monitoring from the regulators. In addition, an industry driven EI model is extremely important for a developing country scenario. There is often lack of sophistication when analyzing EI related research for developing countries (del Río et al., 2016). Developing countries require a different treatment for their environmental issues compared to developed countries (Fikru, 2014). Therefore, the industry specific EI provides greater sophistication when analyzing environmental issues in developing countries and assist in prescribing industry specific solutions to those problems. Hence, taking into account theories and literature from the field of industrial economics and strategic management, this study explores the state of EI, its determinants and framework for the chemical manufacturing industry in Malaysia.

1.2 Environmental Developments in Malaysia

This section analyses environmental data and a large strand of environmental policies (i.e., industry driven) to support the problem statement. This section focuses on emissions and policies specifically for the energy and industrial processes sector, as these sectors contributed to the largest growth in emissions between 2000 and 2011. Furthermore, these sectors are linked to the manufacturing sector, which is the interest of this study.

1.2.1 Climate Condition in Malaysia

It has been forecasted that climate conditions in Malaysia are projected to progressively escalate for years to come, as the average surface temperature is on the rise (IPCC, 2007; NAHRIM, 2006). To analyze the temperature trend in Malaysia, the Malaysian Meteorological Department (MMD) conducted temperature analysis by plotting temperature trends for the past forty years. This analysis captured 80% of the variation in climate change for four different regions. For the purpose of the study, four different meteorological stations were used to represent each region. The Petaling Jaya, Kuantan, Kota Kinabalu and Kuching meteorological stations represented each of the West Peninsular, East Peninsular, Sabah and Sarawak region respectively (MMD, 2009). The annual mean temperature trend for the four meteorological stations indicated an increasing trend (see Figure 1.1). The temperature trend showed that East Malaysia recorded lower temperature compared to Peninsular Malaysia. For East Malaysia, the average increase in temperature is 0.5°C to 1.0°C, while for Peninsular Malaysia; the increase is 0.5°C to 1.5°C. Among all the four regions in Malaysia, a significant rise in temperature was recorded in the Western Peninsular Malaysia (MMD, 2009).

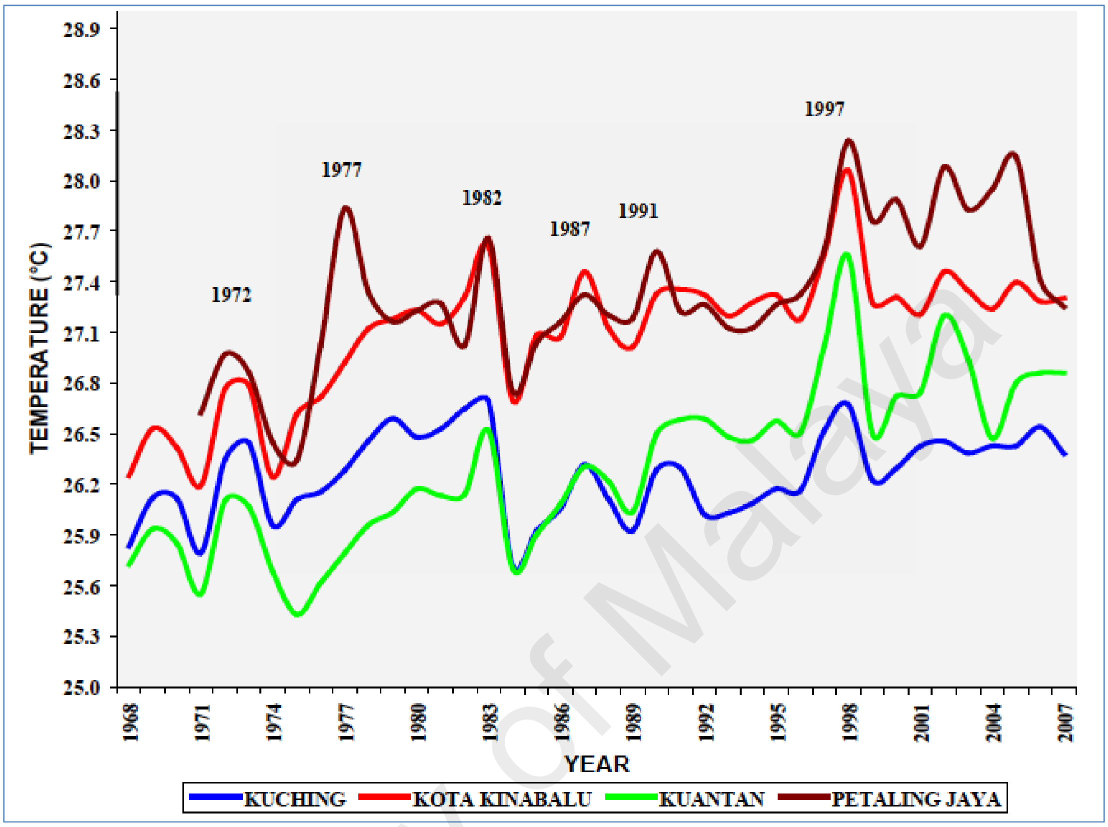

Figure 1.1 : Annual mean temperature trend for four meteorological stations.
Source: Adopted from MMD (2009)

To forecast the temperature in the future, an advanced regional analysis was carried out by the MMD. For the analysis, the climate-modeling tool used by MMD (i.e., Providing Regional Climates for Impacts Studies (PRECIS) model) was developed by the Hadley Center, United Kingdom. The temperature analysis was conducted for three decades namely: first quarter (2020-2029), second quarter (2050-2059), and end of the century (2090-2099) (see Table 1.1). The outcome of the study predicted that by the middle and towards the century's end, Malaysia would experience gradual warming. The simulations indicated higher temperatures in the East Malaysia as compared to Peninsular Malaysia and Sabah, with Eastern Sarawak displaying the highest temperature during the last decade, while Peninsular with the lowest (2.9ºC). The temperature rates doubled from the first quarter to the end of the century. The highest increase is for the Eastern Sarawak region by 2.4ºC and the lowest is for Central Peninsular with an increase of 1.7ºC.

Table 1.1 : Annual mean temperature changes (°C) relative to 1990-1999 period

Region	**2020-2029**	**2050-2059**	**2090-2099**
North-West PM	1.3	1.9	3.1
North-East PM	1.1	1.7	2.9
Central PM	1.5	2.0	3.2
Southern PM	1.4	1.9	3.2
East Sabah	1.0	1.7	2.8
West Sabah	1.2	1.9	3.0
East Sarawak	1.4	2.0	3.8
West Sarawak	1.2	2.0	3.4

Note: PRECIS temperature simulations (HadCM3 AOGCM)
Source: Adopted from MMD (2009)

Besides the increase in temperature, unprecedented rainfalls are expected throughout Malaysia. While it is expected that the Malaysian North East Coastal region may have significant rainfall increase each month, the West Coast, on the other hand would have less. A comparative study of Peninsular Malaysia's East Coast watershed areas between past-recorded levels of river flows and their simulated future flows projected an excessive hydrological upsurge. Even the annual rainfall of Sabah and Sarawak western regions is expected to experience a considerable difference towards the end of the century (NAHRIM, 2006; Tiong, Pereira, & Pin, 2009; Wan Azli, Mohan, & Kumarenthiran, 2008).

There are several adverse impacts towards the Malaysian economy if a rise in the temperature is not controlled. It is projected that for every 2ºC increase in temperature causes rice yield to decrease by 13% or RM200 million. For the palm oil sector, a similar rise in temperature above the optimum level leads to 30% reduction in the yield. Meanwhile, the rubber production yield is expected to decrease by 10% if rise in annual temperature is beyond 30ºC combined with decrease in rainfall (EPU, 2011a; NRE, 2011). Therefore, climate change is real; Malaysia faces catastrophic events like floods, drought and haze, which frequently occurs. Immediate precautionary steps need to be taken as Malaysia is already facing losses in revenue, decline in productivity, facing food security threat and health risk due to climate change (EPU, 2011a).

1.2.1.1 Anthropogenic Forcing

Natural and anthropogenic forcing is identified as factors responsible for global warming. Climatic change over the course of time occured due to, among others, the effect of the natural tilting of the earth's axis and the different changing patterns of relationship between the oceans and the atmosphere spanned several millenniums. Observation based on advanced climate change simulation analysis reported that natural forcing alone could not be attributed for global warming. However, natural forcing in tandem with human induced activities or anthropogenic thrusts, which causes the release of more greenhouses gases (GHG) to the atmosphere have been observed as the contributing factors (IPCC, 2007; MMD, 2009). The main GHG emissions induced by human activities are from the increase in CO_2, CH_4, and N_2O. This in return has caused extreme weather events due to rise in the sea water level and fluctuating ambient temperature.

Table 1.2 : Greenhouse gas emission indices for Malaysia

	Unit	2002	2005	2011	% Increase (2005-2011)
Population	Million	23.3	26.1	29.1	11.49%
GDP at constant 2005 prices	Billion RM	431.234	543.578	711.760	30.94%
CO_2eq emissions	Mil tonne	197.703	262.996	287.740	9.41%
CO_2eq emissions per capita	tonne/capita	8.399	10.076	9.888	-1.87%
CO_2eq emissions per GDP	tonne/thousand RM	0.4538	0.4838	0.4043	-16.43

Note: Calculation based on approach 1, without LULUCF
Source: adopted from NRE (2015)

Anthropogenic forcing factors have moved Malaysia from being a Nett Sink nation in 2000 to a Nett Emitter in 2005, 2007 and 2011. The trend is increasing due to a rapid increasing of industrialization with over dependence on non-renewable energy resource. Malaysia creates a sum of 9.1 PgC/y of which 45% is discharged to the atmosphere, the balance is sequestered by the forest (29%), and into the sea (26%) (EPU, 2011a). From 2005 to 2011, GHG emissions increased by 30.94%, standing at 711.760 mil tonne (see Table 1.2). In terms of per capita emissions and carbon intensity emissions, 9.89 tonne CO_2eq/capita and 0.41 tonne CO_2eq/GDP was recorded respectively in 2011 (see Table 1.2). From 2005 to 2011, improvement in both per capita emissions (-1.8%) and carbon intensity emissions (-16.43%) was recorded, but at global platform, these figures are alarming.

According to the Climate Change Performance Index (CCPI) results, Malaysia is categorized under the very poor forming nation category. The CCPI is computed for 58 countries, which are collectively responsible for 90% of the global carbon emissions (energy-related CO_2). For the year 2014 and 2015, no countries were ranked at the 1st, 2nd and 3rd position, as none of the countries were taking extremely serious steps to mitigate dangerous climate change (Burck, Marten, & Bals, 2015). In 2015, Malaysia was ranked 52, one rank lower compared to 2015 from a total rank of 61. Furthermore, Malaysia's ranking among the 15 newly industrialized countries also worsened in 2015, falling to 14th position as compared to 13th the prior year. However, Malaysia's ranking within the ASEAN countries including India, China, Japan and Korea improved in 2015, from a total of 9 countries Malaysia was ranked at 6th position as compared to 7th in the previous year (Burck, Marten, & Bals, 2014; Burck et al., 2015).

1.2.1.2 Emissions in the Energy Sector

For Malaysia, the energy sector is the highest emitter of GHG. Between 2000 and 2011, the emissions in the energy sector increased by 48% (see Figure 1.2a). Besides the energy sector, during the same duration, emissions in the industrial process sector, agriculture sector, water sector, LULUCF, and net removal increased by 46%, 35%, 45% and 14% respectively. Among the GHG, CO_2 was the major source of emissions in 2000, 2005 and 2011 accounting for 73%, 76% and 72% respectively (NRE, 2015).

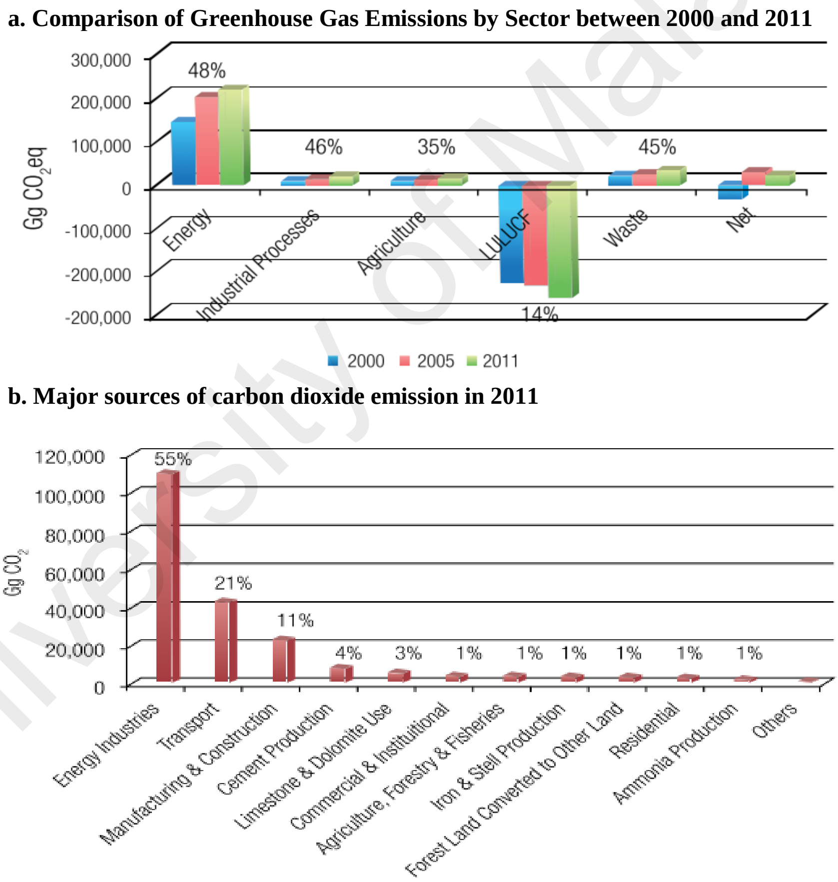

Figure 1.2 : Greenhouse gas emissions by sector between 2000 and 2011
Note: Percentage indicates the % emission increase/decrease between 2000 and 2011. LULUCF=Land use, land use change and forest-induced by human activities
Source: Adopted form NRE (2015)

Among the major sources of CO_2 emitters, the energy industry contributed to the highest share of CO_2 in 2011 at 55% (see Figure 1.2b). This was because fuels utilized by auto and power producers were mainly for natural gas transformation, petroleum refining and electricity (NRE, 2015). Among the other top emitters were transport sector with a share of 21%, followed by manufacturing industries and construction, at 11%.

According to the final energy consumption data, the largest energy consumer is the transport and industry sector (see Table 1.3). From the total energy consumption of 46,709 ktoe in 2012, the transport and industry sector consume 17,180 ktoe (36.8%) and 13,919 ktoe (29.8%) respectively. According to the annual average energy consumption from 1991-2012, the energy consumption from the transport sector (12356.5 ktoe) is higher than the industry sector (11,664 ktoe). However, based on the statistical data the high demand for energy keeps switching between the sectors during certain intervals.

Table 1.3 : Final Energy Consumption by Sectors in ktoe

Year	Industry	Transport	Residential and Commercial	Non-Energy Use	Agriculture	TOTAL
1991	5835	5806	1721	1071	130	14563
1992	6455	6226	1891	1222	391	16185
1993	7012	6558	2069	2027	62	17728
1994	7486	7262	2300	1817	422	19287
1995	8341	7827	2556	2994	446	22164
1996	9834	8951	3162	1744	486	24181
1997	10106	10201	3072	2298	490	26167
1998	10121	9793	3314	2023	307	25558
1999	10277	11393	3653	1799	106	27228
2000	11406	12071	3868	2250	104	29699
2001	11852	13138	4049	2378	98	31515
2002	12854	13442	4387	2511	96	33290
2003	13472	14271	4400	2345	98	34586
2004	14913	15385	4754	2183	87	37322
2005	15492	15384	5134	2173	101	38284
2006	15248	14825	5429	2809	253	38564
2007	16454	15717	6196	2958	281	41606
2008	16205	16395	6205	2876	287	41968
2009	14312	16119	6336	3868	211	40846
2010	12928	16828	6951	3696	1074	41477

Table 1.3 : Final Energy Consumption by Sectors in ktoe - continue

Year	Industry	Transport	Residential and Commercial	Non-Energy Use	Agriculture	TOTAL
2011	12100	17070	6993	6377	916	43456
2012	13919	17180	7494	7494	1052	46709

Source: Malaysia energy statistics handbook (EC, 2014)

Next, based on the emission time series data the three major emitters of the energy sector are the energy industries, transport sector and manufacturing industries and construction (see Figure 1.3). Among them, emissions from the energy industries are the largest, with the emissions level increasing from 39.6% in 2002 to 52.0% in 2011. At the second position is the transport sector; this sector's emissions of the energy sector are 24.3% in 2000 and 20.2% in 2011. Then, followed by the manufacturing industry and the construction industry, which showed an increasing trend until 2007 and decreased gradually. In 2007, this subsector contributed to 24.3% of the total emissions of the energy sector in 2007 before plunging to 10.6% in 2011 (NRE, 2015).

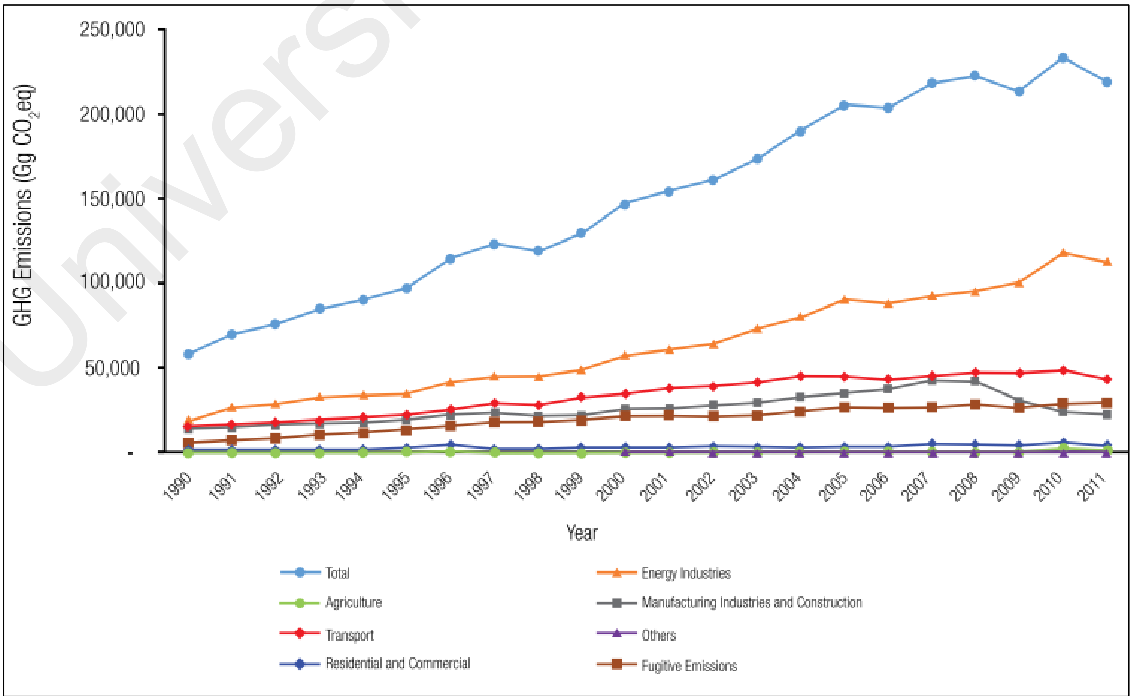

Figure 1.3 : Emission time series from 1990 to 2011 for energy sector
Source: adopted from NRE (2015)

1.2.1.3 Emissions in the Industrial Processes Sector

The second sector that requires due attention is the industrial processes sector. This sector recorded the second highest GHG emissions between 2000 and 2011 after the energy sector at 46% (see Figure 1.2a). Furthermore, considering Malaysia as an emerging industrial entity, greater emissions are expected from this sector in the future. Among the industrial processes sectors, the minerals products industry recorded the highest emissions, which was primarily from the cement production and with the use of limestone and dolomite (see Figure 1.4). In 2000, the emissions from the mineral products was 78.7% of the total emission of the industrial processes, while in 2011 was 71.9% (NRE, 2015). Metal industry and chemical industry are other two industries that relatively contributed to the total emissions of the industrial processes sector between 2000 and 2011. For the chemical industry emissions was mainly from the production of petrochemicals and ammonia. While for the Metal industry the emissions were principally from iron and steel production (NRE, 2015).

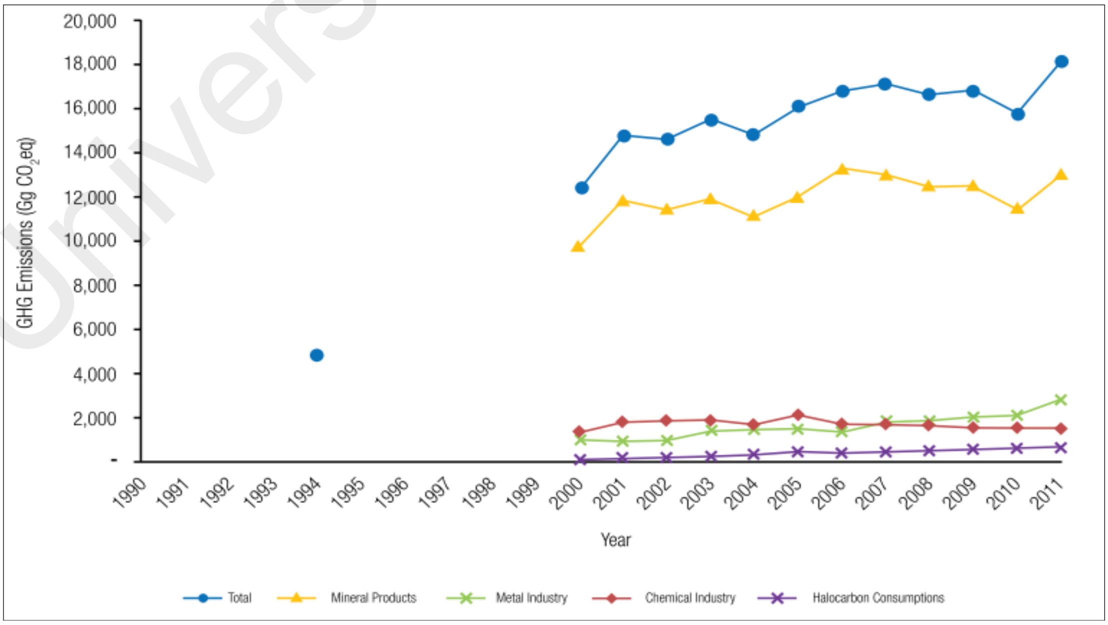

Figure 1.4 : Emission time series from 2002 to 2011 for industrial process sector
Source: adopted from NRE (2015)

In this section, by evaluating the historical environmental data it was evident that surface temperature in Malaysia has increased and is expected to escalate by the end of the century. Various adverse effects of climate change like prolonged drought and frequent floods are being experienced by Malaysia, which has imposed a huge tool on the economy and well-being of the citizens. The highest emissions are from the energy and industrial processes sector with the former leading the emissions level. Within the energy sector, it was found that the energy industries, transport and manufacturing industries are contributing to the total emissions of the energy sector. While for the industrial processes sector, industries that are mainly responsible to totals emissions of the sector are the mineral, metal and chemical products industry. In the following section, the policies primarily used to reduce emissions and promote EI for the energy and industrial processes sector are assessed.

1.2.2 Action Taken by Malaysia- Policy Evaluation

In this section, emissions reduction and green technology policies for the energy and industrial processes sector are brought forward. The shortcomings related to the policies are also discussed.

1.2.2.1 Policies for the Energy Sector

The initial innings to retaliate against the deteriorating environment was addressed in the Third Malaysia Plan (1976-1980). The efforts were further intensified after the release of Brundtland report (i.e., Our Common Future) in 1978 and the Rio Conference in 1992. Since then, Malaysian has progressively formulated policies to fight climate change. Malaysia invested in the environmental issues by incorporating environmental concerns into the development plans ever since environmental pressure groups, multilateral treaties and United Nations started pressuring countries around the globe to priorities climate change as their national agenda (Hezri & Nordin, 2006). Currently, Malaysia is strongly committed to environmental conventions under the United Nations Conference on Environment and Development (UNCED), especially the United Nations Framework Convention on Climate Change (UNFCC). In the following paragraphs, a sectorial assessment on the policies and initiatives to reduce emissions and promote EI are discussed.

From the previous section, it is evident that the largest emissions were from the energy sector. From the very beginning, acknowledging the need for resources conservation and the need for renewable energy (RE) resources the government provided attention to the energy sector. The major five energy policies are the National Petroleum Policy (1975), National Energy Policy (1979), National Depletion Policy (1980), Four-Fuel Diversification Policy (1981) and Five-Fuel Policy (2001). These policies reduced Malaysia's dependency on oil resources to generate electricity by expanding the energy supply mix, which included RE. The inclusion of RE in the energy supply provided more RE and energy efficiency (EE) centered policies as following: National Biofuel Policy (2009), National Renewable Energy Policy (2010) and National Green Technology Policy (2009). These policies strategically shall cultivate RE in the country especially from solar, biomass, biogas and mini hydro. The current aim for RE generation based on The Sustainable Energy Development Authority (SEDA) is 985 MW or 5.5% by 2015 and 2080 MW or 11% by 2020. To encourage the industry participation in RE development, fiscal initiative such as income tax exemption (i.e., Pioneer Status) and investment tax allowances were given. Among the successful RE projects are the Small Renewable Energy Power Programme (SREP), Malaysian Building Integrated Photovoltaic Project (MBIPV), Feed-in Tariff mechanism, Biomass-based Power Generation and Cogeneration the Palm Oil Industry (BioGEN) and others (see Figure 1.5). However, RE and EE initiatives in Malaysia are still new and a lot of projects are still in progress (i.e., entry point projects (EPP) under the government's Economic Transformation Programme (ETP) (NRE, 2015).

ENERGY SECTOR	
Policies 1.National Petroleum Policy 1975 2.National Energy Policy 1979 3.National Depletion Policy 1980 4.Four-Fuel Diversification Policy 1981 5.Five-Fuel Policy 2001 **RE & EE Focus** 1.National Biofuel Policy 2009 2.National Renewable Energy Policy 2010 3. National Green Technology Policy 2009 4.New Economic Model 2010	**Initiatives** 1.Cap on oil & natural gas 2.RE meet 5% energy demand by 2005 3.Fiscal incentive: PS & ITA 4.SREP Programme 5.B5 diesel: 5% processed palm oil 6.National Biofuel Act 2007 7.Renewable Energy Act 2011 8. Sustainable Energy Dev. Authority 9. Feed in Tariff (FiT) 10. MBIPV 11. BioGEN-Biomass power generation 12. MEPS for energy efficiency

Figure 1.5 : Policies and initiative for the energy sector

Note: PD=Pioneer status, ITA=Investment tax allowance, SREP=Small renewable energy power, MBIPV=Malaysian building integrated photovoltaic project, MEPS=Minimum energy performance standards

Source: Author

Malaysia is in the verge to harness the full potential of RE resources in the country. It is noted that moving from the initial energy conservation oriented policies to a more RE and EE oriented policies, the government's mission has changed. Where the initial mission was only to reduce emission but now this mission is coupled with the commercialization of green energy technology and green energy related products. Malaysia has partially establish the upstream segment of the RE industry. And is undertaking extensive research and development to uplift the downstream manufacturing segment of RE products such as invertors, hybrid systems and energy conversion tracking systems, solar cell and others (Mekhilef et al., 2012). Therefore, in the future RE will not only assist the reduction of emission, but also promote green growth, which is driven by green energy technologies and green energy related products.

1.2.2.2 Policies for the Industrial Processes Sector

For the industrial processes sector, the major initiative by the government is the enactment of the Environmental Quality Act (EQA) 1974. The legislation under the purview of the act is pollution prevention, abatement and control. Various instruments such as licensing, discharge fees, technology standards, performance standards, monitoring, environmental impact assessment (EIA) and others were used to prevent and control emissions especially among the manufacturing industries. With increasing industrialization, EQA 1974 was reviewed and regulations that are more stringent were imposed. Besides EQA 1974, several other efforts made to promote green technology initiatives within the manufacturing sector. Among them is the introduction of ISO14001 (i.e., was widely adopted by large industries), Cleaner Technology Extension Services (CTES), training courses by Environmental Institute Malaysia (EiMAS) and others (see Figure 1.6). The initiatives taken by the government for emissions reduction is applauded. However, there is a limited scope to cultivate green technology and green products in the manufacturing sector. This is because EQA 1974 is extremely command and control in nature (i.e., enforcement and monitoring), which provided lack of flexibility for firms to innovate. Additionally, major initiatives for cleaner technology are focused on SMEs and large firms are neglected (i.e., that large firms are financially strong and have the capabilities to eco-innovate). Large industries have greater potential to catalyze EI driven economic growth.

Initiative for Manufacturing Industries

1.Environmental Quality Act (EQA), 1974
-Major governing Act
-Enforcement by Department of Environment (DOE)
-Focus on prevention abatement and control of pollution
-Focus area: based water pollution, municipal and industrial wastewater pollution, industrial emissions, motor vehicle emissions, and toxic and hazardous waste management
-Tools: licensing, discharge fees, technology standards, performance standards monitoring, EIA
-Stringency increased over the years

2. Other Initiatives
-SIRIM-Cleaner technology programme for SMEs, Cleaner Technology Extension Services (CTES) and Cleaner Technology Information Service (CTIS)
-Introduction of ISO1400
-Malaysia Agenda for Waste Reduction (MAWAR)-waste management strategies
-Environment Institute Malaysia (EiMAS) provides training courses

Issues

-Regulation is extremely command and control in nature.
-To dependent on enforcement and monitoring
-Lack of involvement from the private sector
-Major initiatives for cleaner technology are focused on SMEs, while large firms have greater potential to catalyst green technology

Way forward:
-Guided self regulation
-Promoting Green industries

Figure 1.6 : Environmental policy for industry
Source: Author and Ismail & Julaidi (2015)

Furthermore, since the inception of the National Green Technology Policy (NGTP) (2009), efforts have been placed to promote awareness, networking and collaboration for green technology. The sectors that received greater attention under the NGTP besides the energy sector are the automotive sector, and the construction and building sector (see Figure 1.7). Minimal initiatives were advocated to promote the EI in the manufacturing sector. Moreover, little attention is emphasized to specific types of EI such as process eco-innovation, product eco-innovation and organizational eco-innovation. Furthermore, a sectorial technology framework is not employed to infuse initiatives and to catalyze on firms existing EI.

The government seems to understand the shortcomings related to the environmental policies in Malaysia. Progressively, the government is expected to address these shortcomings by changing approaches to reduce emissions, by developing a more holistic plan to promote EI in the country as well to encourage EI driven green economic growth. The changes that are ought to take place are presented in the following section.

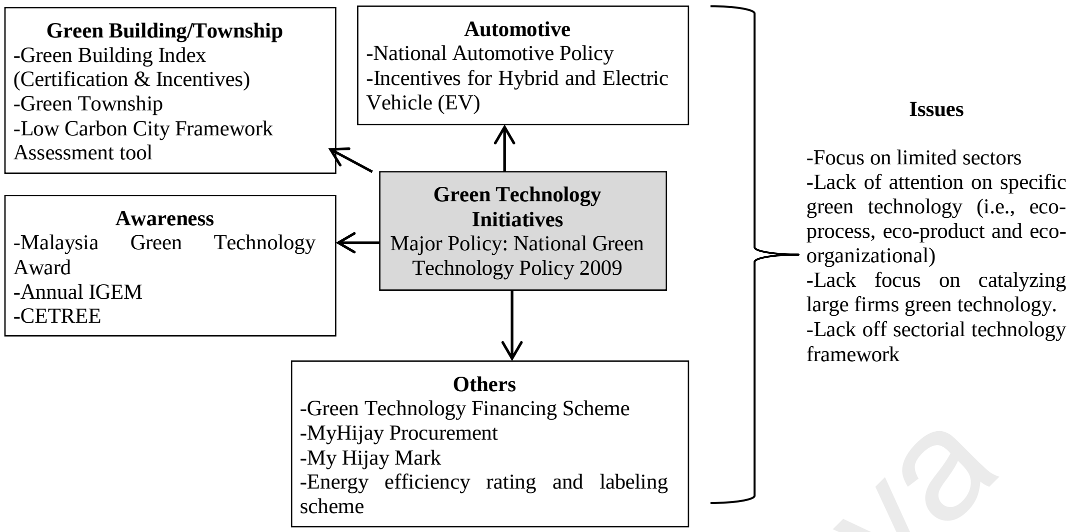

Figure 1.7 : Green technology initiatives (i.e., non-energy related)
Note: IGEM=International GreenTech & Eco Products Exhibition & Conference Malaysia, CETREE = Centre for Education and Training in Renewable Energy and Energy Efficiency
Source: Author

1.2.2.3 Policy Transformation: Opportunities and Challenges

It is projected that in the future the command and control enforcement approach (EQA 1974) will be changed to a more guided self-regulation approach. Efforts to promote green industries and the cradle-to-cradle principle will be intensified (Ismail & Julaidi, 2015), by launching the Green Technology Master Plan (GTMP). The GTMP is expected to provide a more strategic plan to advocate green technology (see Figure 1.8). GTMP will provide an integrated eco-system in greening local companies, which encompasses a framework that will take into account leadership, financial, human capital and technology aspects of firms to produce green products and services. Besides, GTMP will also advocate life cycle thinking, which requires the firms to embrace advanced sustainable manufacturing concepts and practices. Furthermore, sector specific incentives will be provided to industries to meet the national carbon emissions target. These changes are imperative in the case of Malaysia, as Malaysia has committed to the Trans-Pacific Partnership where environment is a key negotiating area. In the future TPPA would impose greater environmental pressure towards the industries.

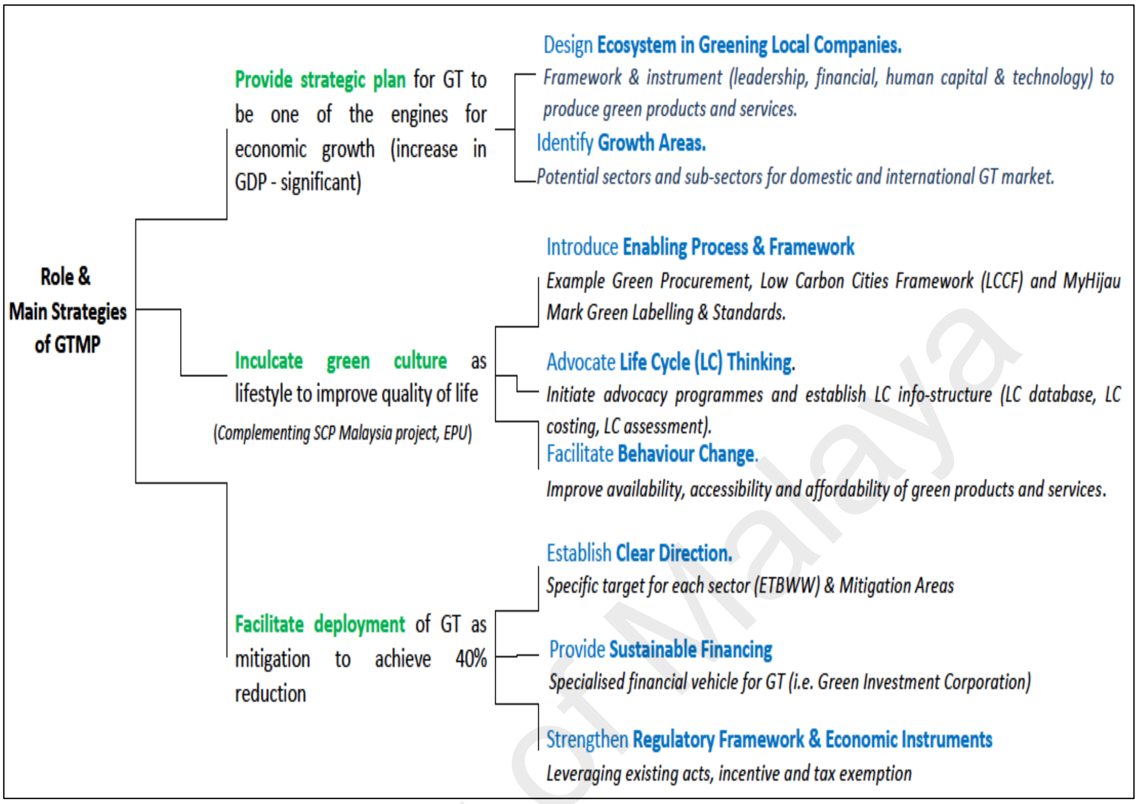

Figure 1.8 : Green Technology Master Plan
Note: ETBWW=Energy, Transport, Building, Water Management and Water Management
Source: Adopted form MGTC (2014)

The GTMP is expected to uplift Malaysia's economy and strategically position the country as a Green Technology Hub (Haris, 2015). Once the GTMP is launched, multiple benefits towards the economy and well-being of the citizens are expected. It is projected that by 2020, green technology contribution to the national GDP will be around 1.2% (RM 22.4 billion), and the contribution is expected to increase in 2030, at 1.5% (RM 60 billion). On the investment front, green investment is expected to increase from RM22.4 billion in 2020 to RM 28 billion in 2030. Furthermore, these investments are expected to create more green jobs, with 144, 590 jobs in 2020 and 211,500 jobs in 2030 (see Figure 1.9). The citizens of Malaysia can expect improved quality of life as more green cities, green jobs, better air quality, healthier society and a sustainable future is projected (Haris, 2015).

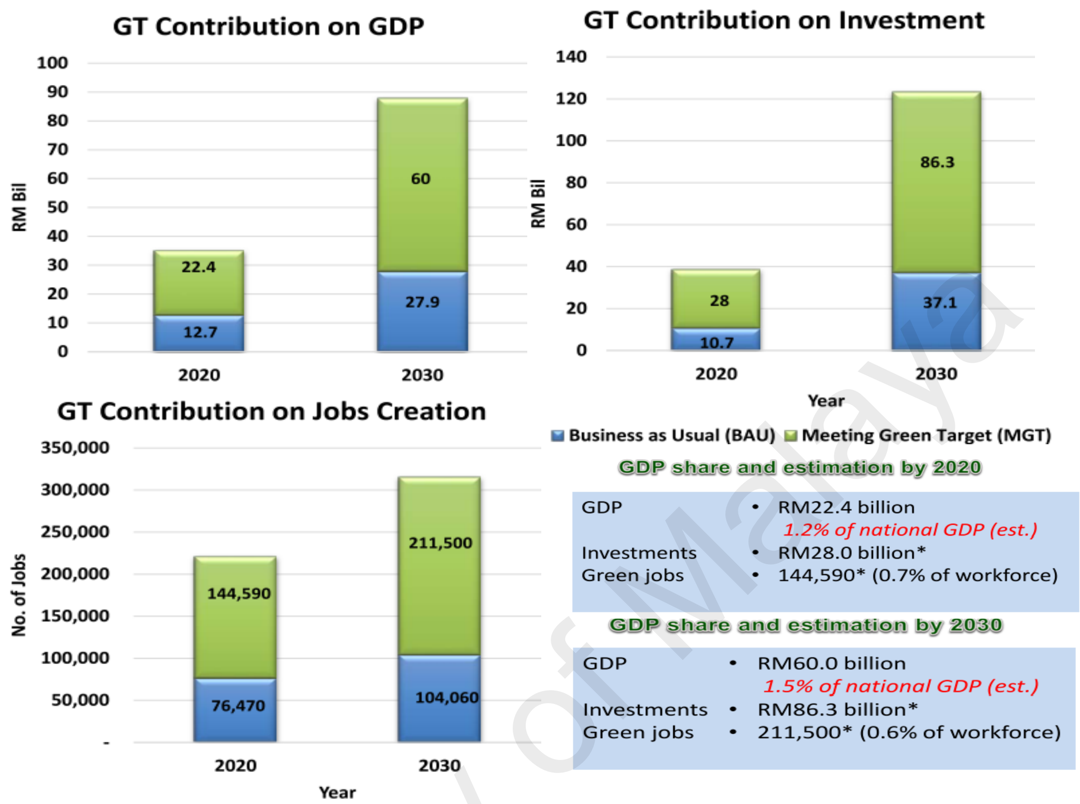

Figure 1.9 : The prospect of Green Technology Master Plan on Malaysian Economy
Source: Adopted from Haris (2015)

The transformation that is about to take place provides more liberty to firms to find solutions to reduce emissions, which automatically promotes EI. The GTMP is expected to provide a more sectorial approach to encourage EI and advocate more advanced sustainable manufacturing concepts and practices (i.e., life cycle thinking) to promote green economic growth. If this proposed transformation is materialized, the benefits are twofold. First, the level of emission will be greatly reduced as the enforcement has moved beyond prevention to control the adoption/creation of improved EIs that has the capability to reduce more emissions. Second, the encouragement and life-cycle thinking approach towards EI will generate multiple economic benefits (i.e., green products, investment, green jobs and others) and drive green economic growth as propelled under the Eleventh Malaysian Plan (2016-2020). However, for the proposed transformation to materialize, several issues as following need to be addressed:

1. Large manufacturing firms neglected

Over the years, large firms were neglected when initiatives and plan to cultivate EI was designed. Clean technological development initiatives and incentives were frequently geared towards the small and medium industries. The reason so, large entities have the financial and managerial capabilities to eco-innovate. Ignoring the financial capability, the government need to capitalize on other technological capabilities that large firm have developed. These firms have the technological framework and strategies that could be infused with EI driven policies to proliferate the level on EI. By intervening in the already established technological framework of large firms, the government can effectively reduce the emission level and increase EI initiatives among firms. According to the National Environmental Policy, large firms are supposed to facilitate SMEs through partnership schemes to eco-innovate (MOSTI, 2002). However, the economic managers do not emphasize on this aspect seriously. The manufacturing sector is the second largest sector that contributes to the national GDP. Therefore, large manufacturing industries requires due attention from the policy makers. These industries will not only largely bring down the emissions level but also effectively drive green economic growth.

2. Industry driven EI framework

Researchers involved in climate change policy formulation in Malaysia highlighted several issues, which was either based on the own experience or according opinions by others (i.e., viewpoints from various stakeholder regarding the formulation and implementation of the National Policy on Climate Change). From all the issues, three main issues were imperative to be reviewed in this study. The first issue is that there is lack of participation from the stakeholders and major groups that are directly or indirectly linked to climate change thus eroding the ability to implement responses to climate change (Tan et al. 2009). Furthermore, there is no a suitable framework is yet to be derived to enable stakeholders and policy-makers to form a network and communicate, which could then play a major role to assist in creating national policies that would be relevant (Al-Amin et al., 2013). The second issues was concerning policy harmonization where climate change policy and guide and integration plans implementing climate-proof developments that are drawn up are not in tandem with the current policies (Pereira & Subramaniam, 2007). The final issue is that sector specific actions are required for better climate change policy results (Tiong et al., 2009).

Industry driven EI framework is required in order to increase stakeholder participation, harmonize climate change policies with existing policies and to implement sector specific actions. Firms developed own framework that conveys technology capabilities together to innovate. The understanding of the framework is required to determine the most imperative EI determinants, which are currently unknown. Under the GTMP, an integrated framework is proposed in greening local companies, which takes into account the EI determinants (i.e., leadership, financial, human capital and technology drivers). However, for effective GTMP outcomes, the framework has to be industry specific because it differs from one industry to another (Fikru, 2014). Through the framework, policy makers are able to identify stakeholder's role in cultivating EI. A proper network and communication channel could be formed between stakeholders and policy-makers to effectively coordinate climate change actions. The technology frameworks embraced by firms are in response to previous policy. Therefore, the understanding of the framework and stakeholders' responsibility allows for better harmonization between climate change policies and existing policies.

In conclusion, industry specific driven EI framework is necessary to effectively increase stakeholder's participation, harmonize climate change policies with existing policies and to implement sector specific actions as advocated under the GTMP.

3. Life-cycle-thinking approach

The way forward for environmental policies in Malaysia is the provision of guided self-regulated mechanism, which provides firms a greater liberty to eco-innovate. The GTMP advocates life-cycle-thinking approach that encourages the society to embrace advanced sustainable concepts and practices to eco-innovate. The current state EI has to be identified for firms to effectively embrace these new approaches to reduce emissions and eco-innovate. Information pertaining the current state of EI would encompass the types of EI that the firms are creating or adopting, and the sustainable manufacturing concepts and practices adopted. From this information, policy-makers are able to determine the intensity of actions required for firms to embrace life-cycle-thinking approach. The shift towards advanced sustainable manufacturing concepts and practices is necessary to move the industries toward a green ecosystem.

1.3 Problem Statement

In the 21st century, climate change is a great challenge faced by governments around the world (Gerstlberger, Praest Knudsen, & Stampe, 2014). Malaysia is not spared from this global phenomenon as according to the past and present climate data, the average surface temperature in Malaysia in on the rise (IPCC, 2007; NAHRIM, 2006). Considering the intensity of emissions, environmental policies and initiatives has always favored the energy sector. In contrast, the manufacturing industry that is responsible for substantial emissions of the energy and industrial process sector (NRE, 2015) is not emphasized. Major regulations under the Environmental Quality Act 1974 assisted the enforcement of pollution prevention, abatement and control in the manufacturing industries. The regulation is command and control in nature, which provides limited flexibility for firms to eco-innovate. Furthermore, initiatives and actions to cultivate EI are focused on SMEs. In fact, large organizations have greater potential to effectively develop EI and drive the government's agenda to promote green economic growth. This is because these organizations have established technology capabilities and framework (De Marchi, 2012; Przychodzen & Przychodzen, 2015; Zhu, Dou, & Sarkis, 2010). Manufacturing sector is the second largest sector that contributes to the Malaysian GDP. By exploring the technology framework of large manufacturing industries, and infusing the framework with the EI policy action would effectively contribute to EI, reduce emission and foster green economic growth.

By understanding the shortcomings related to the environmental policies, in the future, command and control enforcement approach (EQA 1974) will be changed to a more guided self-regulation approach, which also includes the promotion on green industry and the cradle-to-cradle principle (Ismail & Julaidi, 2015). Additionally, A Green Technology Master Plan (GTMP) will be launched soon, which will advocate a sector specific integrated eco-system for EI, which encompasses firm EI determinants and life cycle thinking approach. For this transformation to promote EI to reduce emission and to catalyze green economic growth, several gaps need to be filled. The present problem is that there is no holistic sector specific EI framework and the imperative EI determinants are unknown. Furthermore, there is no account on the current state of EI and the role of large manufacturing firms to intensify EI and the green growth is ignored. The information is necessary to effectively increase stakeholder participation, harmonize climate change policies with existing policies and to implement sector specific actions, which is advocated under GTMP.

1.4 Research Questions

To fill the research gaps and to examine ways large manufacturing industries would effectively promote EI, several important research questions are addressed in this study. The questions are:

1. What is the state of eco-innovation in the chemicals manufacturing industry?
2. What is the best-integrated framework to drive eco-innovation in the chemical manufacturing industry?
3. What are the underlying factors driving eco-innovation in the chemical manufacturing industry?

The concern of the first research question is to gauge whether EI is taking place in firms. If the EI activity is present, then are the firms involved in all three types of EIs (i.e., product EI, process EI and organizational EI). This question also provides information on the intensity of EI in terms of creation and adoption. Additionally, through this research question the state of EI is investigated according to three aspects, namely: firm's ownership type (i.e., domestic, foreign and state), headquarters location (i.e., domestic or foreign) and export destination (i.e., to countries with stringent or lax environmental regulation). Finally, the manufacturing concepts and practices embraced by the firms will also be addressed.

The second research question focuses on exploring the EI determinants thoroughly to understand the influence of the EI in the firms. As the EI determinants are the technology capabilities that the firms have developed over the years, it is expected that through this question, the decision-making flow, influence of the top management and the mechanics that governs the EI process would be addressed. The information obtained will assist in determining the linkages between each EI determinants and the entire building block of the EI framework for the chemical manufacturing industry.

For the third question, the EI framework will be tested empirically. This question will indicate the most imperative drivers of EI that require attention from business managers and policy makers.

1.5 Objectives of the Study

Specifically, this study has the following objectives:

1. To assess the state of eco-innovation in the chemical manufacturing industry.
2. To explore the eco-innovation framework in the chemical manufacturing industry.
3. To examine the determinants of eco-innovation in the chemical manufacturing industry.

1.6 Research Philosophy

Pragmatism is the guiding philosophical paradigm for this study. The discussion of the philosophical worldview at the initial stage of the research, prepared the researcher to deploy justifiable actions to complete the study. There are four types of main worldviews or epistemological camps namely: post-positivism, constructivism, advocacy/participatory, and pragmatism (Creswell, 2009). Pragmatism worldview is more problem-centered. In order to derive knowledge from a particular issue, pragmatist deploys a pluralistic approach to diagnose the issues and to find solutions. Additionally, pragmatists are not constrained by any single philosophy, and have the freedom to choose any method of enquiry that is best suited to solve the problems. Therefore, pragmatism philosophy is the best guiding principle for researchers who employ a mixed method enquiry, as they are able to use varied techniques, worldviews and distinct assumptions to solve their research problem. This philosophy allows flexibility, as there is always overlapping philosophy and methodologies that govern the research process (Christ, 2013).

There are several specific reasons for selecting this philosophical worldview. First, study that revolves around environmental issues is sensitive in nature. Such information, if not correctly presented has the capability to tarnish the image of an organization, and due to this reason, firms may reveal sufficient information. Thus, by using qualitative and quantitative enquiry increases the possibility to obtain greater amount of information. Moreover, combining different strategies in collecting multiple data increases the quality of the research outcome (Johnson & Turner, 2003).

Next, the mix of different designs has the capability to answer specific research questions. This study looks into the micro level issues; it explores the internal and external factor that combines the firm's capabilities and resources. It is a challenging task to capture the relevant information especially in the environment where the experience, culture and attitude differ. Therefore, varied techniques are required to capture the relevant information.

Finally, this study explores a workable solution to environmental issues. Since, this study deals with environmental technology, decision-making has to be quick and effective as technology becomes obsolete in a short span of time. A pragmatic approach was preferred as it allows close engagement with industry participants (human enquiry) to drive the right solution, rather than taking a rigid stand solely based on certain theories or past findings to minimize skepticism.

1.7 Research Strategy

The sequential exploratory design was finalized as the research design for this study. This design was chosen as lack of solid instrument and measure available to gauge EI for developing countries specifically. Secondly, essential variables to be included in the EI framework are not explicitly defined. Therefore, an in depth exploration and detail understanding of the dimensions was required to avoid misspecification. Additionally, this study focuses on the chemical and chemical manufacturing cluster, thus a detailed understanding of the cluster is required to understand their managerial and production mechanics to suggest appropriate remedies to promote EI after data analysis.

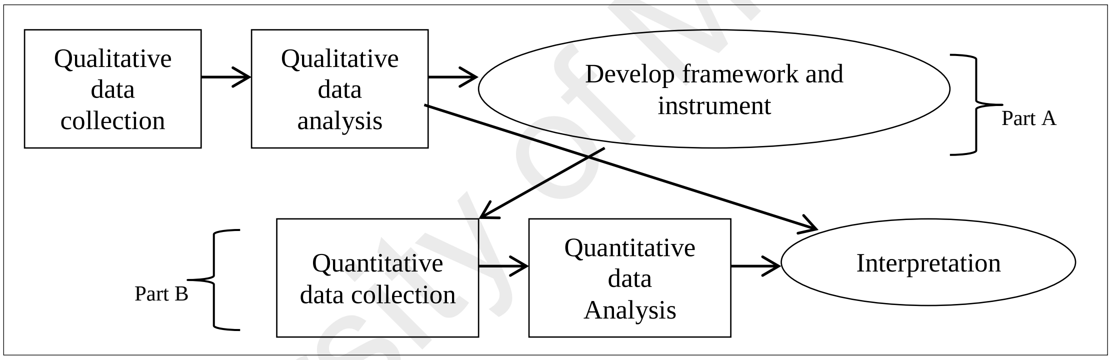

Figure 1.10 : Sequential Exploratory design
Source: Adapted from Creswell & Clark (2011)

There are two parts to sequential exploratory design, part A and part B (see Figure 1.10). In Part A, Several interviews were conducted in selected firms to measure the state of their EI activities and to explore predetermined EI determinants within the context of the chemical manufacturing industry by gathering their resources and capabilities. This avenue was also used to explore other environmental related emerging issues. The first part strengthened the conceptual model and the development of instrument (questionnaire). Part B deals with quantitative data collection for a larger sample of population and data analysis. Finally, information from both part A and part B was used to interpret the findings. The information from both the qualitative and quantitative strands enabled the researcher to propose recommendations that are more sophisticated.

1.8 Contribution

By using a qualitative and quantitative route consistently to assess EI, this study is expected to add new knowledge to the existing literature. The primary objective of this study is to enhance the existing literature in the field of EI and the determinants of EI. This knowledge will assists in merging theories from different fields to provide more practical and radical solution to eco-innovate, which is currently lacking.

Firstly, this study extends the innovation aspect of theories stemming from environmental economics, innovation economics and strategic management specifically into the field of EI. From the literature review, it was found that major innovation related theories namely theory of induced innovation, evolutionary economic theory, resource-based theory, dynamic capabilities theory and stakeholder theory have to work collectively to effectively stimulate EI. Neo-classical theory that drives environmental economists largely examined the effects of environmental policy instruments that stimulate EI. The dynamic efficiency criterion emphasized to establish whether specific environmental policy instruments (i.e., pollution charges, subsidies and other) provide an incentive for firms to eco-innovate. However, the modeling is done within ideal conditions (i.e., where the economy is competitive, exhibit low transaction cost and quickly adapts), whereby the present condition does not permit the modelling. A realistic EI framework is required for a better understanding of the emitter's structure (Janicke, Blazejczak, Edler, & Hemmelskamp, 2000).

To understand the emitter's structure, the demand and supply of the EI factors require due considerations. These shortcomings in the environmental economics are addressed by evolutionary approach of innovation economics that emphasized the importance of technology push and demand pull factors to promote EI (Pavitt, 1984; Rennings, 2000). Innovation economics needs to be complemented with major strategic/organizational management theories like resource-based view (Wernerfelt, 1984), dynamic capability theory and stakeholder theory (Freeman, 1984) for an established EI theoretical framework. A holistic EI framework that incorporated diverse EI determinants, with a strong foundation from the field of economics and management is yet to be constructed (del Río et al., 2016). Therefore, this study intends to fill this gap by integrating innovation theories and knowledge from environmental economic, innovation economics and strategic management by developing a holistic EI framework. This initiative, furthermore, indirectly contributes in advancing innovation literature in all the three fields.

Secondly, this study seeks to establish a sector specific EI framework for the chemical manufacturing industry. Researchers have claimed that a holistic EI framework is necessary to align firms existing technological capabilities, so that the EI initiatives could be effectively executed (Adams et al., 2016; Cheng et al., 2014; Inigo & Albareda, 2016). The framework has to be industry specific (Oltra, 2009; Schiederig, Tietze, & Herstatt, 2012), and exhibit strategic linkages between the EI determinants (del Río, Peñasco, & Romero-Jordán, 2016). This is because, innovation is outcome of the complex systems (Grubb, 2004) and the level of eco-innovation is expected to be different across sectors (Montalvo, 2008). Furthermore, for Malaysia specifically, a suitable framework is yet to be derived to allow stakeholders and policy-makers to form a network and communicate, which could then play a major role to create relevant national policies (Al-Amin et al., 2013). Therefore, this study fills the gap by establishing a sector specific EI framework by taking into consideration nine imperative EI determinants from the literature. The framework consists of three sub-models.

Through the framework, prime drivers that assemble firm capabilities and resources to influence eco-innovation are identified.

Thirdly, besides developing the framework, this study also seeks to measure the state of EI and the sustainable manufacturing concepts and practices embraced by the chemicals, and chemical products manufacturing firms. In Malaysia currently, there is no account of specific types of EI created or adopted by firms. Furthermore, a large number of firms have not registered their eco-innovations with the Intellectual Property Corporation of Malaysia (MyIPO). Due to the lack of patent data, it is difficult to determine the intensity of the eco-innovations transpired within the chemical industry. Therefore, this study contributes by determining the type of eco-innovations (i.e., process, product and organizational) introduced by firms between 2010 and 2015, and their intensity (i.e., creation or adoption). Additionally, the interviews provided an avenue to ascertain the sustainable manufacturing concepts and practices employed by firms in order to churn these innovations.

This study also has several imperative policy implications to develop a more holistic plan to promote EI in the country and to encourage the EI driven green economic growth. This study employs both qualitative and quantitative approach to examine the relationship between EI and its determinants in the local context. Thus, this study will provide information that is more comprehensive for policy makers to design effective environmental policies. Since this study is sector specific and qualitatively engages with firms, there is large of amount of implication drawn from firm’s strategic behavior and managerial practices. This information provides the policy makers a better understanding of firm’s capabilities and routines involved in shaping the environmental strategies. Furthermore, organization and management studies emphasized that the understanding of organizational factors, such as the culture and structure of a firm, are essential to understand the reaction of firms toward external conditions and design solutions in solving problems (Howard‐Grenville, Nash, & Coglianese, 2008). Therefore, with substantial firm level information provided in this study, policy makers are able to harmonize public environmental policies with corporate environmental policies to increase its effectiveness. This is because with similar corporate and public environmental goals to achieve, firms have sufficient time to plan and avoid misallocation of resources (Johnstone, Haščič, & Kalamova, 2010). Additionally, as this study extensively deals with chemical manufacturing industry, a thorough review was conducted to examine the nature of the industry and its performance. The information provided on the chemical industry in Chapter 3 will assist the policy makers in designing a more robust sector specific environmental policy.

Lastly, for developing economics, a complete study was not attained to provide a holistic view of the drivers and mechanics of EI in developing countries (del Río et al., 2016). Thus, this study seeks to enhance the literature on environmental economics and innovation economics by examining environmental policies and drivers of eco-innovation in the context of developing countries.

1.9 Organization of the Study

The study is organized as follows. Chapter 2 previews the important theories and literature related to eco-innovation. The chapter also presents preliminary hypothesis and framework generated by thoroughly engaging with the literature to assists the qualitative enquiry. Prior progressing with the qualitative and quantitative enquiry, an overview of the Malaysia chemical manufacturing industry is presented in Chapter 3 to provide an understanding of the chemical industry structure and its performance. Next, to provide easy of understanding, the qualitative and quantitative inquiry is separated.

Chapter 4 exhibits the qualitative research design and followed by the results and discussion in Chapter 5. The refined eco-innovation framework developed in Chapter 5 is empirically tested in Chapter 7. Prior to the quantitative finding, the research design is presented in Chapter 6. Lastly, policy implications and future research direction is highlighted in Chapter 8.

CHAPTER 2 : LITERATURE REVIEW, THEORIES, PRELIMINARY HYPOTHESIS AND FRAMEWORK

2.1 Introduction

The purpose of this chapter is to extract relevant information related to EI and its determinants. This information will be used to derive the preliminary hypothesis and EI framework. The reason for attaining preliminary knowledge is due to large amount of EI related research available based on developed countries. Furthermore, there are huge differences in national innovation systems, the level of firm's involvement in solving environmental issues and consumers willingness to pay for environmental products between countries (del Río et al., 2016). Thus, these disparities are expected to increase when comparing developed and developing countries. Replicating models, frameworks and outcomes from these researches to a new environment could lead to false judgment. Therefore, the purpose of this preliminary knowledge is to provide the basis to explore EI in the context of developing countries.

This chapter is not only confined to exploring issues and supporting evidence pertaining to EI and its determinants, but also identifies potential theories as the foundation for the EI framework. Preliminary hypothesis and eco-innovation framework are discussed at the end of the chapter.

2.2 Eco-Innovation

Technological change is an evolution of technology that occurs from invention, innovation, and diffusion. Invention is the initial process where an idea is expanded scientifically or technically to develop new processes and products. Whereas, innovation is the second stage whereby the newly developed processes, or products are readily available in the market. Lastly, in the diffusion stage, the processes and products are widely used by clients (firms and individuals) (Schumpeter, 1942). In a broader context, technological change from the perspective of environment refers to the latest technological development in terms of processes, products, system and practices, which will reduce environmental damages (del Río, 2009). Two common definition of EI referred and extended by scholars conducting research in the are of sustainable innovation are as following:

1. Environmental Technology Action Plan (ETAP)

“The production, assimilation or exploitation of a novelty in products, production processes, services or in management and business methods, which aims, throughout its lifecycle, to prevent or substantially reduce environmental risk, pollution and other negative impacts of resource use (including energy)” (OECD, 2009c, p. 226).

2. OECD/Eurostat Oslo Manual

“The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations” (OECD and Eurostat, 2005, p. 46). This definition is used to collect data for both EI and general innovation. However, the following additional features are given to EI: “It is innovation that reflects the concepts, and emphasizes on a reduction of environmental impact, whether such an effect is intended or not”(OECD, 2009a, p. 13).

Technological change takes place at two different intervals, either at the beginning or at the end of the production process. Cleaner production technologies refers to technologies that are installed at the initial stage of the production process to mitigate pollution right form the beginning till the end of the production process (del Río, 2009). End of pipe technologies are measures/tools that are placed at the final stage of production process to mitigate harmful environmental pollutants. These technologies can be easily purchased and does not require a major change in the production process (Bernauer, Engel, Kammerer, & Seijas, 2007). The EI being the solution to environmental problems to a larger extent is undisputable. By using a Marshallian demand framework, Sohag, Begum, Abdullah, & Jaafar (2015), analyzed the effects of technological innovation on energy used in Malaysia. By employing an ARDL technique to test the empirical model using patent counts as proxy for technological innovation, the study found that technological innovation plays an imperative role in increasing energy efficiency and reducing energy use. Additionally, the study also indicated that substantial replacement of the old technology is important for Malaysia to reduce the level of carbon emissions and to increase the economic growth.

Scholars from various disciplines have examined policy mechanics, and firm technology capability enhancing drivers that have superior quality to promote EI (Brunnermeier & Cohen, 2003; Cuerva et al., 2014; Currin, Program, & Law, 2011; del Río, 2009; Demirel & Kesidou, 2011; Jaffe & Palmer, 1997; Popp, 2001; Porter & Linde, 1995a). Since then, the term sustainable innovation has evolved, and now known as eco-innovation. EI, moreover, is a more sophisticated definition of sustainable innovation currently used in academic literature (Rennings, 2000). However, several other terms are still used interchangeably by researchers to reflect EI such as environmental innovation and green innovation. This study will employ the term EI in reference to any technological development that reduces environmental harm either directly or indirectly.

There are a several types of eco-innovations, namely, process eco-innovation, product eco-innovation, organizational eco-innovation and marketing eco-innovation (Kemp & Arundel, 2009; OECD and Eurostat, 2005). This study focuses on the first three main types of eco-innovations as suggested by literature (Horbach, 2008; Triguero et al., 2013), as marketing eco-innovation is still evolving. The three types of eco-innovations are summarized in Table 2.1.

Table 2.1 : Types of eco-innovation

Type of EI	Description	Source
Process EI	• An improvement or a new addition in the production process that changes or alters the way a product is manufactured. • Minimize environmental harm during the production process. • Promote efficient usage of resources (cost reduction). • Gives an impact toward operational activities • Example: scrubbers, water treatment technologies, green energy technology.	(Cheng et al., 2014; Docter, Van Der Horst, & Stokman, 1989; Kemp & Arundel, 2009; Negny, Belaud, Robles, Reyes, & Ferrer, 2012; Rennings, 2000)
Product EI	• Development of new products or improvement on the existing features of the products (technical component and material). • Undertaken to ensure environmental harm is reduced throughout the product life cycle • Satisfying evolving market needs (environmentally sound society) • Example: New eco-products, eco-buildings/house.	(Bernauer et al., 2007; Carrillo-Hermosilla, del Río, & Könnölä, 2010; Kemp & Arundel, 2009)
Organizational EI	• This type of innovation does not have direct impact towards reduction in environmental harm (focus: organizational management process). • Facilitates and coordinates the technical knowledge in coming up with environmental innovations. • Impact firm work activities and the entire infrastructure. • Example: Pollution prevention schemes, EMAS, ISO14001.	(Bernauer et al., 2007; Birkinshaw, Hamel, & Mol, 2008; Cheng et al., 2014; Kemp & Arundel, 2009)

Rennings (2000) stated that limiting EI to only product, processes, marketing methods and organizational methods is no longer practical. Innovation in social and institutional structures should also be taken into consideration. Increasing deployment of EI and the internalization of environmental values by various quarters of the society has increased the boundaries for EI. Therefore, the benefits that EI generates are much more widespread, thus EI need to be captured from this large spectrum.

Radical EIs that successfully achieve pollution reduction targets are an amalgamation of a properly structured technological products, process and systems, plus, overwhelming institutional support (Boons, Montalvo, Quist, & Wagner, 2013; Huesemann, 2003). Therefore, the R&D unit churning EIs will not effectively solve environmental problem. It is the collective responsibility of the entire organization to support EI initiative (Brunnermeier & Cohen, 2003). Moreover, organizations need to understand the relationship between each type of EIs, to holistically tackle environmental issues (Cheng et al., 2014).

2.2.1 Importance of Eco-Innovation

The concept of "green utopia" coined by the United Nations Environment Programme (UNEP) provides an impetus to recognize the priority given to EI to solve environmental issues. UNEP defines "green utopia" as "an ideal state of affairs. A green economy does not generate pollution or waste and is hyper-efficient in its use of energy, water, and materials" (UNEP, 2008, p. 35).

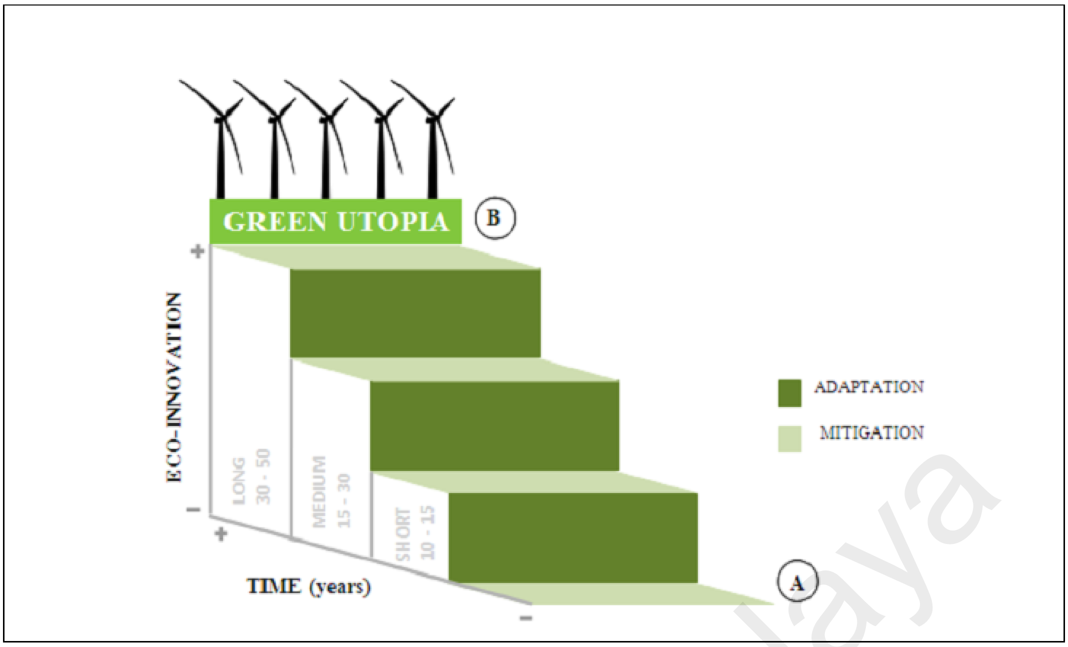

Figure 2.1 : The stairway to 'Green Utopia'
Source: Adopted from (Martinez-fernandez & Hinojosa, 2010)

With reference to Figure 2.1, point B, which is at the highest level of the stairway, is "green utopia". In addition, the journey from point A to point B clearly denotes that it requires a substantial amount of commitment, resources and time from the society. Moreover, this climb is impossible without EI, which is the pillar and strength of the stairway. Therefore, moving towards "green utopia" is impossible without timely effort form every quarters of the society by embracing the importance of EI in this transition (Martinez-fernandez & Hinojosa, 2010).

EI arrived at the perfect timing, especially at time where humans' behavior of ignoring the Mother Nature has retaliated against them. Increasing carbon emission, excess exploration of resources, poor waste disposal habits, hazardous chemical manufacturing practices and other activities have created serious apocalypse for mankind. EI has the capability to restore the damage made towards the socio ecological system.

EI allows the conservation and regeneration of resources by improving the resources efficiency. Schmidheiny (1992) refers this as “eco-efficiency”, which is the production of economically valuable products and services that meets the market demand through the employment of fewer resources, thus minimizing the ecological impact of their production. The notion of eco-efficiency brings forward a strategic proposal for firms to incorporate environmental issues into their business practices. Any move or action that firms take be it with their external or internal stakeholder, firms need to embrace EI. These practices progressively increase the standards of efficiency and reduces firms footprint on the environment. Therefore, eco-innovation has a huge potential to increase eco-efficiency (Machiba, 2010).

Burgeoning scarcity of resources and energy coupled with global warming calls for a new perspective on growth. Future demand for green economy growth models (i.e. “green utopia”) that takes into account both business and environment issues (Ahlstrom, 2010; Nidumolu, Prahalad, & Rangaswami, 2009). With regards to economic growth, Schumpeter (1934) emphasized on the gravity of innovation for growth. Eco-innovation is a valuable component to reconstruct the innovation system within the new growth model, taking into account the whole green ecological perspective. For this new growth models to prosper and create wealth for the society, it depends of long-term sustainable EI processes (Carrillo-Hermosilla et al., 2010). The most striking outcome of this new EI infused green growth models is that it will have an inbuilt system, which is capable to internalize negative externalities arising from the environment. Thus, the fact that EI is the backbone of “green utopia” cannot be discarded.

EI has raised new opportunities by giving birth to new industries, jobs (Machiba, 2010) and better competitive position (Porter & Linde, 1995b), which is required for green economic growth to progress. Firms are taking advantage of this transformation by adding value to their business and creating their of own niche to remain competitive (Lozano, 2015). Plus, through EI firms are also able to offset costs induced by environmental regulations.

2.2.2 Reasons to Measure Eco-Innovation

The importance of EI to promoting sustainable economic development is undisputable. Measuring EI and exploring its strategic position within firms, EI framework is essential to provide input to various stakeholders. So that, these stakeholders would quickly implements suitable strategies to move in tandem with the sustainable transformation that is taking place in their country and globally. However, measuring EI and understanding the EI framework is not an easy task, as the level of EI is different across sectors (Montalvo, 2008). The innovation is outcome of complex systems. Therefore, consolidated information from different levels of supply chain and market feedback is vital to measure EI (Grubb, 2004).

In this section, reason to measure EI highlighted by Kemp & Arundel (2009), are explored in further detail to have an in-depth understanding of these reasoning. It is imperative for a country to measure the state of EI, as the concepts and practices of sustainable manufacturing are evolving overtime. To achieve the state of green utopia, economies are required to move away from EIs that merely treat pollution and embrace EIs that synergies industrial ecology (see Figure 2.2).

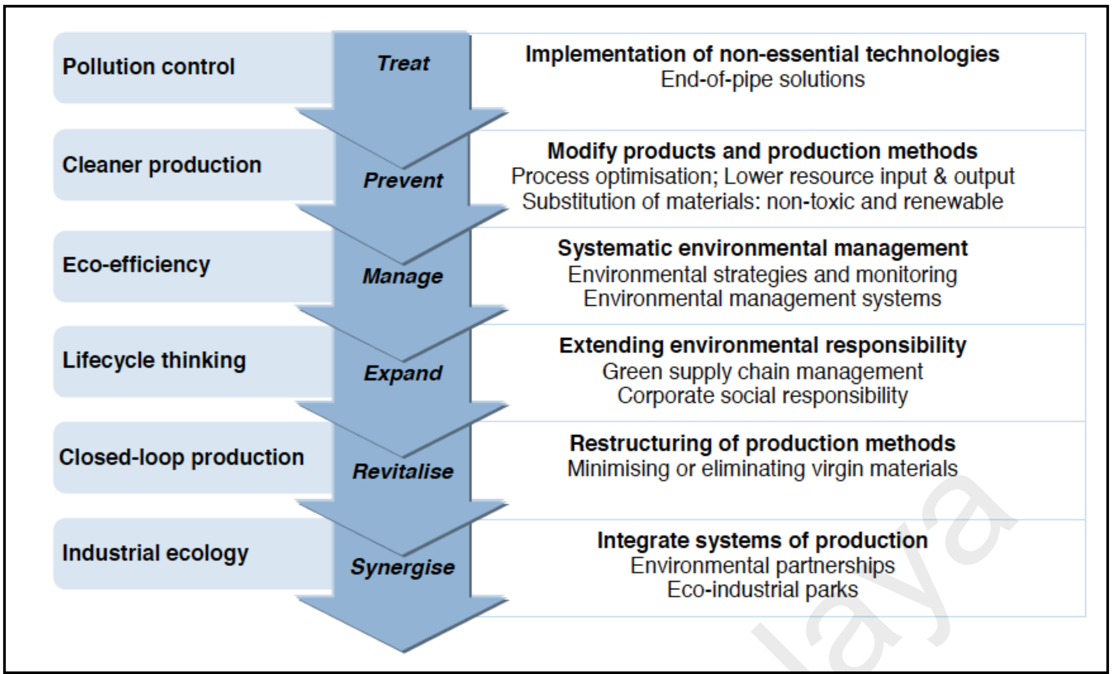

Figure 2.2 : The evolution of sustainable manufacturing concepts and practices
Source: (OECD, 2009a)

Therefore, determining the over all trend and practices in EI (i.e., creation, adoption, increasing, decreasing and transition such as from pollution control to lifecycle thinking) are important for policy makers, business managers and several other stakeholders for the following reasons:

i. To understand at which stage of transformation that EI has taken (i.e. pollution control, life cycle thinking and others).
ii. To understand the trends and practices in EI locally and globally (i.e. increasing or decreasing).
iii. To gauge the performance of public and corporate environmental policies.
iv. To compare their environmental strategies with other countries.
v. To set new benchmarks for future environmental strategies (i.e. treat, prevent and others).

The interface of sustainable manufacturing is changing rapidly. Thus, other sub aspect of EI such as the determinants need to be measured as well (OECD, 2010). The knowledge pertaining to EI determinants assists policy makers and firms to design the EI framework. Furthermore, this information allows policy makers and firms to strengthen the imperative EI determinants, and invigorate weaker determinants in their building future technology capabilities. Additionally, understanding eco-innovation is important as some forward-thinking firms that are adopting new business models which incorporates environmental concerns (Boons & Ludeke-Freund, 2013; OECD, 2009b). The policy makers, on the other hand, can formulate policy that enhances firm level determinants that would automatically promote EI initiatives among them rather than stringent technology forcing mechanism.

Lastly measuring eco-innovation provides environmental awareness to other stakeholder and consumers. Increasing the information about the potential and benefits that would be harvested from EI increases the interest of stakeholders to be part of its development. This attracts financial investment, collaboration and technical assistance to elevate benefits harvested from EIs. Furthermore, measuring EI increases consumer awareness on the consequences of their purchase and lifestyle towards the environment. Greater consumer awareness and realization to protect the environment further increases the demand for EI.

2.3 Theories

The importance of technological progress for economic growth gained greater momentum since the work of Joseph Schumpeter. Schumpeter argued that a dynamic process governs the economic development influenced by innovation, whereby, old technologies are substituted with new – i.e. “creative destruction”. He also differentiated between “radical” innovation and incremental “innovation”. The former was touted causing chaotic changes while the latter was seen to be more progressive in advancing the change process. With this theories and views, the next question arises; why this change (innovation) was important. The industrial organization theory by Tirole (1988) strongly proposed that innovation was essential for firm to remain competitive and to venture into new areas that allow greater competitive advantage. Firms’ mission to improve their market position through innovation automatically increases performance in terms of cost reduction and improved material efficiency. Product differentiation that takes place further strengthens the competitive advantage. Thus, industrial organization posited that innovation bring a bundle of benefits to the firms.

The trajectory of EI issues lies between the borderline of two economics sub-discipline; the environmental economics and innovation economics (Rennings, 2000). The merger of this two sub-discipline is necessary to build a robust EI framework. Environmental economics theories propagated through the mainstream neo-classical view, which emphasized that increasing prices encourage the discovery of new technology. Based on the induced innovation literature (Ahmad, 1966; Hicks, 1932), the increase in input price through environmental regulation encourages the firms to reduce the usage of these resources. The inflated cost has the capability to induce the creation or adoption of EI. Environmental economic, therefore, provides a powerful basis to scholars to evaluate different environmental policy tools. The postulation of environmental regulation as the driver of EI under the environmental economics realm have seen the inception of the famous Porter-hypothesis (Porter & Linde, 1995b). Porter-hypothesis gauges three different aspect of environmental regulation to promote eco-innovation namely, regulation in general, flexibility and stringency of environmental regulation. Evolutionary innovation theory is the foundation for porter hypothesis (Horbach, 2008). On the other hand, Nelson & Winter (1982) influenced the technological change to a new different level by reconfiguring the fundamental microeconomic model such as the production function and predictable firm behavior as a 'routine'. The underlying mechanics of their framework is the search for superior techniques, and the selection of most outstanding innovation by the market.

Thus, it is evident that innovation theories are motivated by Schumpeter and advanced by neo-classical economics into environmental economics. The reconfiguration of fundamental macroeconomic model into routines by evolutionary innovation theory was the gateway that bridges the gap between environmental economics and innovation economics.

Innovation economics, on the other hand, deals with rapidly changing factors that influence the decision to eco-innovate (Rennings, 2000). Innovation economics shifts the attention from input prices to firm's internal and external conditions that influence innovation. Firm's organizational structure, organizational learning, consumer behavior and access to knowledge are several factors that influence firms decision to innovate (OECD and Eurostat, 2005). Management theories play an integral role especially to evaluate firm's internal and external innovation drivers. Thus, innovation economics ventures into management theories to explore the drivers of eco-innovation. Management theories that scholars used to explore EI determinants are resource-based view (Wernerfelt, 1984), dynamic capability theory and stakeholder theory (Freeman, 1984). Innovation economics revolves around ascertaining issues pertaining to whether technology push or market pull factors drives EI (Pavitt, 1984; Rennings, 2000).

2.3.1 Theory of Induced Innovation

Theory of wages by Hicks (1932) laid the foundation for theory of induced innovation. Hicks propagated that increase in wages influence firms to search for alternative resources and economize on the input that is relatively more expensive. Ahmad (1966) reinvigorated Hicks's work by using a comparative static approach to disagree with the critics and present the theory of induced innovation with greater sophistication. Hicks and Ahmad, the forerunner of the theory of induced innovation paved the way for scholars to assess the relationship between the environmental policy and eco-innovation. Researchers build their case accordingly, where change in the relative price of factors may affect the nature of EI. In the EI framework, environmental regulations increase the cost of compliance and inflate the input price. This encourages the firms to eco-innovate in order to reduce cost and increase the profit margin. Environmental regulations acts as a mechanism to inflate the opportunity cost of using an environmental asset, as market fails to place a price on them (Johnstone et al., 2010).

2.3.2 Porter Hypothesis

Porter & Linde (1995b) posited that firms innovate under dynamic competitive conditions rather that static. The transition toward sustainable economic development is still evolving. The real process of dynamic competition is often characterized by incomplete information and organizational inertia toward technological change (Porter & Linde, 1995a). Thus, environmental regulation supports this transition through the following ways (Porter & Linde, 1995b): (1) to provide signal of resource inefficiencies that is taking place, (2) to raise awareness, (3) to decrease uncertainty related to environmental investment, (4) to assert innovation, (5) to provide a level playing field for firms, whereby, environmental innovation assists in gaining position, and (6) to stringent regulation for greater innovation.

Taking into account the impact of environmental policy towards innovation, Porter and Linde (1995b) emphasized that stringent but “properly designed environmental regulation can trigger innovation that may partially or more than fully offset the costs of complying with them” (Porter & Linde, 1995b, p. 98), which was later known as the Porter hypothesis. The important concept in Porter-hypothesis is “innovation offsets”- i.e. innovations that reduce the cost of environmental standards compliance. Furthermore, Porter and Linde (1995b) suggested that this innovation could fuel growth and enhance competitiveness (Ambec, Cohen, Elgie, & Lanoie, 2013).

2.3.3 Evolutionary Economic Theory

Evolutionary theory of technical change accentuates the transformation that a firm endeavor through the actions between economic agents which stems from various interactions and experiences over time (Dosi, 1982; Nelson & Winter, 1982). The “Schumpeterian” idea was brought forward into the evolutionary perspective of technological change, where technological change process is more dynamic in nature and not static.

The dynamism that is involved in churning innovation is path-dependent and transpires through cumulative actions (Arthur, 1989; Dosi, 1982; Ruttan, 1997). Present dimension of technology and knowledge is the outcome of past choices of techniques and routines employed by firms and its synchronization with dominant economic conditions. However, technological change needs to go beyond the current path models to progressively grow and avoid lock-ins (Ruttan, 1997). Imitation, local search process for innovation and satisficing behavior are events that lead to technological change (Nelson & Winter, 1982).

2.3.4 Resource Based Theory (RBT) & Natural Resource Based View (NRBV)

Since the expansion of research in the area of eco-innovation and firm's competitive advantage (i.e. with the inclusion of environmental dimension), resource-based view (RBV) has contributed toward an influential theoretical framework for linking firm's internal and external resources in supporting the EI process (Cainelli, De Marchi, & Grandinetti, 2015). RBV deals with study where a firm's competitive advantage is determined by their bundle of unique resource endowments and their strategy to compete is structured based on this resources (Conner & Prahalad, 1996).

Firm's resources can be inferred as the cumulative strength created based on the firm's assets, which allows a firm to formulate and implement their value creating strategies. Firms are endowed with heterogeneous resources (Penrose, 1959), where this heterogeneity allows them to have a persistent competitive advantage over time. Meanwhile, resource immobility is another factor that enables a firm to capture its competitive edge against other firms. Exclusive internal innovation capability of the firm, with budding resource capacity strengthens the strategic position of a firm (Barney, 1991). Superior competitive advantage (technology, consumer loyalty and others) enables firms to create a barrier of entry. This competitive advantage itself is a resource that allows firms to acquire higher returns (Wernerfelt, 1984, 1995). Moreover, The distinct advanced system and structure developed by firms garner higher returns by offering lower cost and stellar quality products in the market (Teece, Pisano, & Shuen, 1997).

Firms need to match their internal resources and skills, while being aware of the external opportunities and risk to be distinctive in their approach to capture their market share. Continuous exploitation of firms' specific assets and review of their strategies are important to retain the niche in the market. In lieu to that, assessment of the international and local business environment in terms of technological change, changing customer's demand and public policies are important. Moreover, the identification of unique attributes of the firm's resources and complementing them with the changing economic environment is the key thrust of the RBV (Conner, 1991; Grant, 1991; Hobday, 2005).

On the other hand, natural resource-based view (NRBV), which is the hybrid of RBV, needs to be given due attention when environmental issues are in the forefront. Hart (1995) emphasised this expansion by including the natural environment into RBV. According to Hart, "strategy and competitive advantage in the coming years will be rooted in capabilities that facilitate environmentally sustainable economic activity" (Hart, 1995, p. 991). Where firms are required to pay additional attention to several issues such as greater transparency in dealing with business and environmental issues, collaboration fosters advanced eco-innovations and stakeholder integration to tackle the environmental issues. Above all, Hart (1995) also expressed the importance of interconnectedness to acquire resources.

RBV emphasized that firms needs to focus on core competencies. In the context of environmental innovation studies, taking into consideration NRBV, these competencies are in the form of green skills, environmental knowledge, strategic collaborations, effective environmental strategy and others, which transpires into effective eco-innovation process. Later, these competencies raise the barriers to imitation due to the difficulty to replicate these resources and provide a competitive edge for the firms.

2.3.5 Dynamic Capabilities Theory

Firms that survive and stand out in the competitive global marketplace are have given timely attention to technological innovation. In addition, these firms also integrate current internal and external competencies using their superior management capabilities. The notion dynamic could be expressed as the agility and ability of the firm's strategies, to rapidly respond to the changing economic environment in terms of innovation, regulations, consumer demand and others. The notion of capabilities refers to the ability of the strategic management to amalgamate their internal and external resources and competencies in facing the changing economic environment (D. Teece & Pisano, 1994). Thus, dynamic capabilities are an important endeavor for firms, to prepare and design strategies for competitive survival.

To supersede their rivals in their own distinct and unique way, firms need to continuously assess the market. Important assessments that need to be made are in terms or technological change and the availability of best business practices available for adoption. Firms have to calibrate their market changes into their internal unique resources and develop routines that are unable to be imitated by other competitors. This will give the firms their competitive advantage and are occasionally indicated as "high flex' (Teece et al., 1997; Teece & Pisano, 1994; Winter, 2003).

Dynamic capabilities approach gives attention to firm strategies that focuses on process, positions and path that a firm establishes using its unique characteristics. Firms need to renew their competence for continues competitive survival. Thus, firms need to be abreast with the changing economic environment and deliberately configure on upgrading their internal niche resources. This will in return allow firms to develop value creating management strategies that are not only distinct but promises survival (Teece et al., 1997).

2.3.6 Stakeholder Theory

Stakeholder theory emphasizes that firms need to take into account the interest of a broader spectrum of individuals and groups in their decision-making rather than focusing only on meeting shareholders' needs (Donaldson, Preston, & Preston, 1995; Freeman, 1984). Stakeholders are referred to as "any group or individual who can affect or is affected by the achievement of the organization's objectives" (Freeman, 1984, p. 46). However, firms need to only focus on a narrow list of stakeholders who have a legitimate interest in the organization (Hillman & Keim, 2001) or else the firms might economically perish serving unnecessary interest groups or individuals (Mitchell, Agle, & Wood, 1997). Sirgy (2002) codified stakeholders into three groups as following:

1. Internal stakeholders: Employees, management team and board of directors.
2. External stakeholders: Suppliers, shareholders, local community and the environment.
3. Distal stakeholders: Competitors, consumers and government

2.3.7 Bridging Theories for Eco-Innovation Framework

Technology push and market pull factor are elements of innovation that are embedded in early work by Schumpeter (1934). There is collective agreement between scholars that both technology push and demand pull factors need to interact together for effective technological change to take place (Mowery & Rosenberg, 1979). Regulatory push/pull is another factor that is capable of standing on its own to stimulate eco-innovation, and received enormous attention and acknowledgement over the past three to four decades as an important factor of EI (Horbach et al., 2012; Triguero et al., 2013). An established EI theoretical framework that incorporates diverse determinants of EI, which requires the foundation and understanding of diverse economic and management field is yet to be build (del Río et al., 2016).

Thus, to provide substance and fine-tune theories to develop a solid theoretical eco-innovation framework, Table 2.2 summarizes the variables used in this study into the three types of factors as mentioned above. The table also incorporates primary theories that provided supporting knowledge and guided the linkage of each construct. Figure 2.3, on the other hand, exhibits the amalgamation of theories stemming from three different fields, which are environmental economics, innovation economics and management used in developing the theoretical framework. Stakeholder theory and evolutionary economic theory bind all the theories in the formation of the framework.

Table 2.2 : Variable and theories

Variables	Factors/ Theories
Environmental strategy Environmental collaboration Green skills Environmental knowledge Financial	• Technology push: Factors that alters the internal capabilities of the firms, which later influences the materials, technical aspects and manufacturing methods used in production. • Theories: Resource based theory, BT, Dynamic capabilities theory, Evolutionary economic theory & Stakeholder theory
Market pressure Export oriented firms	• Market pull: External forces such as market forces that influence the production decisions made by firms. • Theories: Stakeholder theory, Evolutionary economic theory & Resource based theory
Environmental regulation Regulation stringency	• Regulatory push/pull – The effect of regulation to stimulate innovation. • Theories: Theory of induced innovation & Porter hypothesis

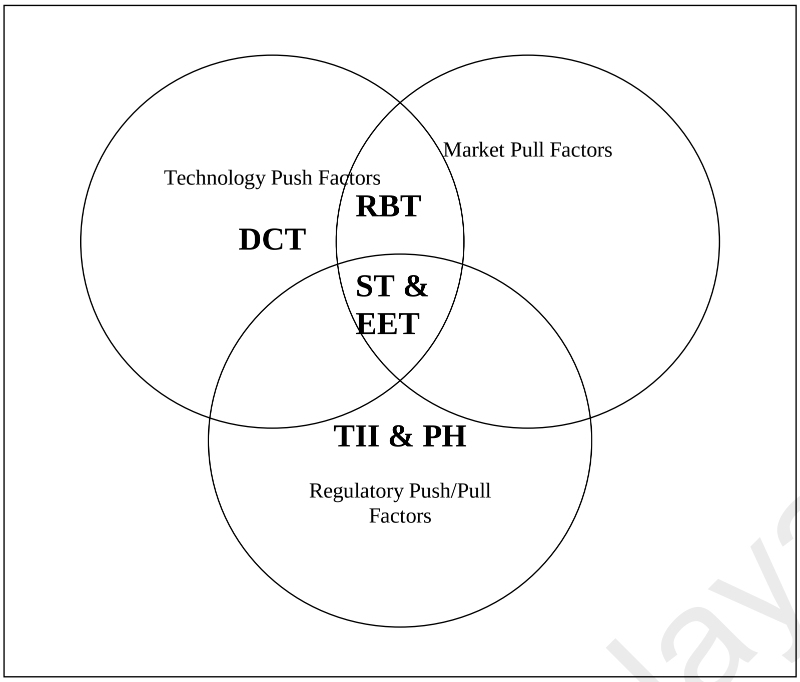

Figure 2.3 : Bridging theories for eco-innovation framework
Note: DCT=Dynamic capabilities theory, RBT= Resource based theory, ST=Stakeholder theory, EET=Evolutionary economic theory, TII= Theory of induced innovation, PH=Porter hypothesis
Source: Author

2.4 Determinants of Eco-Innovation

This section is devoted to explore knowledge pertaining to the determinants of EI. The selection of these determinants are based on extensive study conducted by Del Rio especially in the aspect of exploring firms EI determinants (del Río, 2009; del Río et al., 2016). As majority of the study conducted by Del Rio is in the form of a critical review, it provides an avenue to select the major drivers of eco-innovation. This mode of selection was adopted for two reasons. First, it saved time as we the huge list of EI determinants available were streamlined. Second, attention was given to establish the EI determinants.

The mere identification of these determinants is not sufficient to develop an EI framework. A systemic view of the entire EI process is always important prior to the implementation of EI strategies (Damanpour & Aravind, 2006). Therefore, knowledge on the link of these determinants are linked between and the ability to nurture and support the capabilities within the EI system is critical. The adoption or creation of EI without this knowledge may not be productive. Thus, this section focuses in exploring the direct linkage between the determinants and EI, but also any potential indirect linkage. The theoretical underpinnings of these determinants are also given due attention. Nine eco-drivers are explored, namely: environmental policy, regulation stringency, financial, environmental strategy, environmental collaboration, market pressure, export behavior, green skills and environmental knowledge.

2.4.1 Environmental Policy

Environmental policy is regarded as a superior tool to stimulate the demand for EI (Debnath, 2015; Johnstone, Haščič, & Popp, 2009; Kneller & Manderson, 2012). Studies conducted in various large economies and sectors supported the need for environmental regulation to influence EI, for example, the China automotive industry (i.e. electric vehicle) (Li, Zhan, de Jong, & Lukszo, 2015), European energy sector (Costantini & Crespi, 2008) and U.S. manufacturing industry (Brunnermeier & Cohen, 2003). In addition, environmental regulation, creates competitive advantage (Nishitani & Itoh, 2016) and improves firm performance (Geffen & Rothenberg, 2000). Furthermore, according to Kivimaa (2008b), in certain conditions, EI is the intermediate results of innovation, technology or environmental policies.

There is a large agreement between scholars that environmental policy is important to trigger EI for three superior reasons (Peters et al., 2012). First, EI requires huge amount of R&D funding until maturity as EI encounters knowledge spillovers (Rennings, 2000). Next, there is huge uncertainty on the future returns of R&D investment (Adam, Richard, & Robert, 2002). Last, EIs are exposed to “double externality” (Rennings, 2000), as innovation leads to knowledge spillovers, and new products and process contribute to less environmental externality. This problem hinders investment for EIs (Cleff & Rennings, 1999). Thus, environmental policy plays an important role, primarily by providing the initial momentum in developing eco-innovations. EI needs to be tackled carefully with an amalgamation of both environmental and innovation policies (del Río et al., 2016) due to the "double externality" issues. Effective environmental policies should enable the economy to achieve *Pareto efficiency*[1] and also *cost-effectiveness criterion* (Hahn & Stavins, 1992).

Environmental policies instruments are divided into two categories, environmental regulation and government subsidies. Environmental regulation is separated into two sub-classes namely market-based instruments and command and control regulations, which will be discussed in the next section.

2.4.1.1 Environmental Regulation

Environmental regulation is divided into two broad categories, which are command and control regulations and market based instruments.

1. Command and control regulations (CAC) are prescriptive in nature. They tend to force the firms to strictly comply with regulatory requirement set by the authority. Examples of CAC are performance-based standards and technology based standards.
2. Market based Instruments (MBI) are flexible in nature. They respond to market signal rather than strict directives from any pollution regulatory authority (Fischer, Parry, & Pizer, 2003). Examples of MBIs are pollution charges, tradable permits and market friction reductions.

[1] Maximizing the net benefit of environmental protection.

Many studies were conducted to determine, which regulation regime is superior in promoting EI, MBI's or CAC regulations. There are several studies that confines that CAC regulation provides better platform to influence EI. Research in U.S automotive industry by Lee et al. (2011), found that performance based technology forcing (PBTF) have positive impact on EI in that industry. And PBTF did not only encourage innovation at the assemblers level, but also at the upstream suppliers level. Naoilly (2012) conducted a similar study, to empirically investigate the impact of regulation on EI that promotes energy efficiency in building. Three different environmental regulatory instruments were used in this study, namely: government R&D expenditure on energy, energy taxes, and regulatory energy standards. The results showed that regulatory energy standards induce greater EI followed by government R&D expenditure. While, energy taxes were found to have no impact on EI.

Another important findings within the CAC regulation domain is that firms strongly respond toward performance-based standard rather than technology-based standards to promote EI (Hamamoto, 2006). This is because performance-based standards provide greater flexibility for firms to choose the most cost efficient EI to abate pollution as compared to technology-based standards. Therefore, properly designed CAC regulation is able to increase the flow of investment for EI activities.

In contrast to CAC regulation, there is evidence that MBI have better capability to generate EIs (Downing & White, 1986). Early literature that ranked environmental regulations based on their ability to induce EI found that marketable permits, subsidies, effluent charges and non-technology-based effluent standards contribute to greater EI as compared to technology-based effluent standards. Strong arguments were also extended in defending non-technology-based effluent standards perform better to induce EI, as compared to technology-based effluent standards (Magat, 1979). A similar study, which was conducted after almost a decade to rank five types environmental regulations as following: direct controls, taxes, subsidies, free marketable permits and auctioned permits. The results supported the prior findings that MBI was more powerful in promoting EI. Auctioned permit were seen to lead the race in contributing to eco-innovation followed by emission taxes and subsidies, while free marketable permits and direct controls were found to have the least contribution (Milliman & Prince, 1989). Banking on tradable permits as a measure of environmental regulation, Kerr & Newell (2003) reported that the decision to adopt EI for lead reduction in U.S. oil refineries was stronger under this tradable permit system.

To a certain extent, with the support of extensive literature and evidence, it can be inferred that MBI's are powerful tools to steer EI as compared to CAC regulation. MBI's are favorable due to the flexibility that it offers. Due to that firms have an option to choose the most cost efficient method to mitigate pollution. Plus MBI offers further incentives to heighten efficiency as compared to CA regulation (Williams, 2012). On the other hand, CAC regulation provides limited options and frequently impose mandatory prescription (Johnstone & Hascic, 2009; Popp, Newell, & Jaffe, 2010). One drawback of CAC approach is that once the prescribed technology is adopted, firms have no further tendency to improve or invest in better technology (Lee et al., 2011).

2.4.1.2 Government Subsidies

Government subsidies provide incentives to firms to embark in EI projects and to promote energy conservation. Examples of government subsidies are R&D subsidies, innovation subsidies, tax reductions and energy conservation credits. Research conducted to examine the positive relationship between subsidy and EI have either supported (Horbach, 2008; Veugelers, 2012) or the rejected (Horbach et al., 2012;

Triguero et al., 2013) this relationship. Reasons for studies that rejected this relationship is justified by issues highlighted by Popp (2006b) in his paper, which thoroughly investigated issues related to R&D subsidy. He pointed out that subsidies have the capability to correct market failures especially related to knowledge market. However, they are unable to substantially tackle environmental market failures, which automatically will not influence the adoption of EI. Interestingly, Popp (2006b) showed that subsidies have the capability to uplift the effects of other policies. Similarly Veugelers (2012) found that mixing regulation and taxes with subsidies promotes greater adoption of EI.

2.4.1.3 Regulation Stringency

Environmental regulations that have the strength to circumvent pollution to an optimal level with the aid of eco-innovations, are embedded with a certain level stringency (Johnstone et al., 2010). Stringency refers to "how ambitious is the environmental policy target, relative to the 'baseline' trajectory of emission" (Johnstone et al., 2010, p. 6). Using a duration model, Kerr & Newell (2003) investigate the adoption of technology by 378 U.S oil refineries. Their results indicated that isomerization adoption (lead phase down in U.S) increases about 40% if stringency of environmental regulation is raised through tougher performance based standard. Utilizing data from 2008 executive opinion survey as a proxy for stringency and patent to measure eco-innovation, Johnstone et al. (2012) found that greater regulation stringency has a positive effect on EI. Researches also found that R&D expenditures for eco-innovations are intensifies under stringent environmental regulations (Jaffe & Palmer, 1997). In contrast, the study by Leiter, Parolini, & Winner (2011) indicated that the positive relationship between environmental regulation and EI diminishes as the regulations gets stricter. The argument that they put forward is that stringency works in favor of EI as long as the expenditure incurred to comply with the regulation is lower that the endowed benefits linked to the imposed regulation stringency.

Besides encouraging EI, scholars claimed that stringent environmental regulation spur several other benefits. Firms under stringent environmental regulation domain have an absolute advantage over foreign firms who are not constrained by similar environmental regulations (Porter & Linde, 1995b). Next, countries with stringent environmental regulations are ahead of others in encouraging environmentally friendly technology and products. Lastly, stringent environmental regulation are expected to fasten the process of knowledge spill over, and encourage greater comparative advantage (Costantini & Crespi, 2008).

2.4.1.4 Environmental Regulation Related Issues

Another two emerging issues related environmental policies that needs attention is the flexibility and predictability of environmental regulation. Both this issues are discussed in this section.

2.4.1.4.1 Environmental Regulation Flexibility

Flexibility in environmental regulation has been an important topic of discussion. The fast changing economic environment makes it very difficult for the government and firms to project the future direction of EI. Thus, it is demanding for firms to have greater pollution reduction options. Flexibility in environmental regulation allows firms to carefully choose the best available EI that is cost effective in reducing optimal level of pollution (Johnstone et al., 2010; Porter & Linde, 1995b). Lanoie, Laurent-Lucchetti, Johnstone, & Ambec (2011) investigated the relationship between environmental regulation and EI in seven OECD countries. They found, flexible performance based standards induced greater EIs, as compared to prescriptive technology based standards. The finding supports the narrow version of porter hypothesis, i.e. firms innovate when environmental policies are more flexible as compared to meeting performance standards.

2.4.1.4.2 Environmental Regulation Predictability

Increasing EI is subjected to a well-planned and designed environmental regulation. Any uncertainty associated to it causes the firms to postpone their investment into EIs (Porter & Linde, 1995b; Magat, 1979). An ideal environmental policy should not only be sufficiently stringent and flexible, but also predictable. Predictability of environmental regulation is evident when it has the following three features. First, it should be stable so that it gives investors sufficient time to plan their risky EI investments. Second, it should be targeted in order to avoid any misallocation of resources. Third, it should endlessly give incentives for firms to bring down pollution levels to zero. To induce great EI, government must ensure that environmental polices are predictable (Johnstone et al., 2010).

2.4.1.5 Summary of Environmental Regulation in Malaysia

Since the implementation of the Environmental Quality Act (EQA) 1974, Malaysia has being giving a serious consideration on environmental issues. Environmental actions taken by the government were initiated through various avenues such as specific environmental policies, during every five years Malaysia Plans and government annual budgets plans. Over the years, actions to solve environmental issues have revolved around specific aspects. During the earlier years the focus has been on strengthening of the EQA 1974 and reducing the high dependence on non-renewable resources for electricity generation. Later the attention shifted to promoting green energy sources, which was catalyzed by green energy technologies. In more recent years, while focusing on promoting RE and EE other sectors such as the construction, automotive and agriculture were given attention in terms of sustainable production. Currently, the government is in the verge promoting green technology among a wider spectrum of sectors and in tends to catalyze green technology driven economy growth in the future. The environmental polices and actions undertaken in Malaysia right from 1974 till date is summarized in Table 2.3.

Table 2.3: Summary of environmental policies and initiatives in Malaysia

Policy/Initiatives
Environmental Quality Act (EQA) (1974) - Legislation under the purview of the Act is prevention, abatement and control of pollution. The Department of Environment Malaysia (DOE) handles the enforcement of this act. - Main area of the regulations: Agro-based water pollution, municipal and industrial wastewater pollution, industrial emissions, motor vehicle emissions, toxic and hazardous waste management and environmental impact assessment (EIA).
Third Malaysia Plan (1976-1980) - Government acknowledged that environmental issues needs serious attention. - Progressively environmental concerns incorporated into development plans
National Petroleum Policy (NPP) (1975) - Petroleum Regulation 1974 used to regulate the downstream oil and gas activity. This policy intends to promote greater nation control over the petroleum industry and increase the efficient utilization of petroleum resources.
National Forestry Policy (NFP) (1992) - NFP is in accordance to the call from the global community for the sustainable utilization and conservation of biological diversity. The four main functional forest themes of the policy are protection, production, amenity and research and education. - NFP initiatives are under the preview of Forestry Department Peninsular Malaysia.
National Energy Policy (NEP) (1979) - Supply, utilization and environmental are three main pillars of NEP. Under the first pillar, indigenous energy resources from non-renewable and renewal energy resources developed with the best cost-effective options are supplied, which it both adequate and secure for the nation. The second pillar aims to promote efficient utilization of energy resource and eliminate wasteful energy consumption. Lastly, the environmental pillar deals with minimizing the adverse impact of energy usage towards the environment.
National Depletion Policy (NDP)(1980) - Increasing exploitation of domestic oil and gas reserves evoked the introduction of the NDP to extend the lifespan these reserves. Under the policy, a cap of 6500,000 barrel per day on oil production was imposed (except condensates and natural gas liquids). - Several years later, this policy avenue was used to impose a cap of 2 billion standards cubic feet per day on natural gas reserves.
Fourth Malaysia Plan (1981-1985) - Environmental awareness through greater access to information. - Large R&D investments in palm oil and rubber processing industries promoted indigenous technology treatment technology and increase compliance with increasing stringent standards. - Environmental Quality (Sewage and Industrial Effluent) Regulation, 1979 came into force in 1981. The manufacturing industries manage to reduce Biochemical Oxygen Demand (BOD) by 60% (i.e., through licensing system). - The responsibility to handle solid waste disposal and toxic and hazardous waste management was given to the local authorities. - Industries installed pollution control devices (technology standards) with the enforcement of Environmental Quality (Clean Air) Regulation, 1978. - ASEAN Environmental Programme (ASEP) II (1983-1985).

Table 2.3 : Summary of environmental policies and initiatives in Malaysia-continue

Policy/Initiatives
Four Fuel Diversification Policy (FFDP) (1981)
- FFDP is an addition to the NEP to reduce over dependence on oil, primarily in the electricity generation sector. The strategy was to promote energy supply mix, which consists of hydropower, natural gas, coal and oil.
- The diversification was necessary to ensure reliability and security of energy supply in the long run by balancing the usage of oil, gas, hydro and coal. This policy is revised periodically to avoid the countries over dependence one particular energy source, especially due to 1973 and 1979 oil crisis.
Fifth Malaysian Plan (1986-1990)
- Six types of facilities that required licensing was identified under the Environmental Quality (Scheduled Wastes) Regulations, 1989 (i.e., off-site storage, off site recovery facility, treatment facilities, schedule waste incinerators, secured landfills and land treatment facilities).
- Government provided tax and other forms of incentives to encourage companies to built facilities for the storage, treatment and disposal of waste.
- Formal environmental education and awareness-UPM & UTM introducing degree courses such as pollution control, environmental management, and environmental control technology.
- ASEAN Environmental Programme (ASEP) III (1988-1991).
Sixth Malaysia Plan (1991-1995)
- The Malaysian Institute for Nuclear Technology Research (MINT) development techniques for radioactive waste disposal.
- $40.35 million allocated to DOE to carry out research as well as implement projects for the betterment of the environment.
- Town and Country Planning Department (TCPD)-provide advisory service to improve the environment through landscaping
- Initiation of the National Biodiversity Committee in 1994 to protect the biological resources.
- Standards and Industrial research Institute of Malaysia (SIRIM) conducted cleaner technology programmes for SMEs.
- Business Council for Sustainable Development Malaysia (BCSDM) was set up to promote environment-friendly businesses.
- Commission of Sustainable Development (CSD) monitored Agenda 21 (i.e., voluntary action plan, which is an outcome of United Nations Conference on Environment and Development (UNCED) held in Rio, Brazil, in 1992).
- Malaysia committed to several international conventions: (1) the Framework Convention on Climate Change (FCCC), (2) the Convention of Decertification (3) the Convention on Biological Diversity, (4) the Hazardous Waste and Their Disposal Basil Convention on Transboundary Movement of Toxic and, and (5) the RAMSAR Convention.
- In line with Montreal Protocol, strategy for the reduction of Ozone Depleting Substances was structured.

Table 2.3 : Summary of environmental policies and initiatives in Malaysia-continue

Policy/Initiatives
<u>Seventh Malaysia Plan (1996-2000)</u>
- Improve management of land resource using integrative planning and remote sensing technology.
- Development of forest recreation areas, in which several projects were bilateral international cooperation (i.e., Danish Cooperation on Environment and Development (DANCED), the Japanese International Cooperation Agency (JICA) and the German Deutsche Gessellschaft fur Technishce Zusammenarbeit (GTZ))
- Local Agenda 2I was initiated among four local authorities.
- Environmental management: Promote industries to use clean technology, pollution control equipment and alternative fuel.
- SIRIM set up a Cleaner Technology Extension Services (CTES) and Cleaner Technology Information Service, to conduct environmental audits and establish demonstration projects on cleaner technologies.
- Environmentally related product standards (ISO 14000) were given attention and many large corporations began to display greater environmental awareness, including adopting ISO14001 to ensure that their processes were environment friendly.
- Government launched Malaysia Agenda for Waste Reduction (MAWAR) Programme to encourage industries to formulate strategies to reduce waste.
- In 1997, Malaysian Electricity Supply Industries Trust Account (MESITA) was established, where TNP and the IPPs voluntary contribute 1% of their electricity sale to Grid Fund.
<u>Eighth Malaysia Plan (2001-2005)</u>
- Two projects under the Small Renewable Energy Power Programme (SREP) were implemented.
- Initiation of the Malaysia Building Integrated Photovoltaic Technology Application Project (MBIPV).
- To improve energy savings, energy audits were conducted on eight energy-intensive industries, which was an initiative under the Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP).
- Renewable energy included as the fifth fuel, an extension to the Four Fuel Diversification Policy.
<u>Five Fuel Policy (FFP) (2001)</u>
- During 1999, the review of (FFDP) gave birth to the Five-Fuel Diversification Strategy. This policy includes renewable energy (RE) as an additional energy source to the supply mix in FFDP. This new addition is to encourage the utilization of renewable resources such as solar, biomass, hydro and others. The fifth fuel (RE) was targeted to meet the electricity demand by 2005, at 5%.
- The Energy Commission was given the responsibility to spearhead the RE initiatives, which was mainly governed by the Energy Commission Act 2001 and Electricity Regulation 1994.
- Fiscal incentives for energy conservation are provided. Among the initiatives are Pioneer Status (PS) (tax exemption of 100% of statutory income for 10 years), Investment Tax Allowance (ITA) (100% of the qualifying capital expenditure incurred within 5 years) and tax exemption on RE equipment (i.e., duty import and sales tax).
- Small Renewable Energy Power (SREP) Program (2001) is initiated to assists the RE small power plants to sell electricity through the distribution grid system. This program indirectly promotes the utilization of RE and its distribution in the country (Initiated by the Ministry of Energy, Green Technology and Water).

Table 2.3 : Summary of environmental policies and initiatives in Malaysia-continue

Policy/Initiatives
National Environmental Policy (NEP) (2002)
- NEP is in accordance to eight principles to coordinate economic development with environmental concerns. The principles are (1) stewardship of the environment, (2) conservation of nature's vitality and diversity, (3) continuous improvement in the quality of the environment, (4) sustainable use of natural resources, (5) integrated decision-making, (6) the role of the private sector, (7) commitment and accountability and (8) active participation in the international community.
- The Division of Environmental Management and Climate Change (BPASPI) under the Ministry of Natural Resources is accountable for initiatives executed under the NEP and NCCP.
Ninth Malaysia Plan (2006-2010)
- Greater weight on RE initiatives to ensure the country is in line with the sustainable development agenda.
- In government procurement, green products and services that meets the green standards a given priority.
- Develop Cyberjaya and Putrajaya and the pioneer green technology townships.
- Launch of Green Building Index (GBI) and certification.
- Increase participation in CDM projects and income generated from CER trading will be tax exempted.
- The structuring of Ministry of Energy, Green Technology and Water.
- The setting of Green Technology Corporation to oversee the financing of green technology initiatives.
National Biofuel Policy (NBP) (2006)
- The main objective of NBP is to cultivate RE as perpetuated by other energy policies. The strategic thrusts of the policy are (1) biofuel for transport sector, (2) biofuel for industrial sector, (3) biofuel technologies, (4) biofuel for export sector, and (5) biofuel for cleaner environment.
- B5 diesel, which is a Mix of 5% processed palm oil with petroleum diesel, is used in the transport and industrial sector.
- The National Biofuel Industry Act 2007 regulates the biofuel industry in Malaysia.
National Green Technology Policy (NGTP) (2009)
- NGTP was laid with the quest to promote growth with sound environmental consideration, as proposed by National Outline Perspective Plan. Among the four pillars of the policy are (1) seek to attain energy independence and promote efficient utilization; (2) conserve and minimize the impact on the environment; (3) enhance the national economic development through the use of technology; and (4) improve the quality of life for all.
- Biomass-based Power Generation and Cogeneration the Palm Oil Industry (BioGEN) (2002): Biomass-based power generation biomass and biogas waste from palm oil mill (project executed by Ministry of Energy, Green Technology and Water (KeTTHA)).
- The formation of various labeling and certification: Eco Labeling, MyHIJAU Mark, Energy Efficient Labeling Scheme and Water Efficient Product Labeling Scheme
- Centre for Education and Training in Renewable Energy and Energy Efficiency (CETREE) is an initiative to provide RE and EE awareness to the public especially in schools, universities and through textbooks and competitions.
- In 2009, Green Technology Financing Scheme was established with an initial budget of 1.5 billion.
- Establishment of the National Green Technology and Climate Change Council.

Table 2.3 : Summary of environmental policies and initiatives in Malaysia-continue

Policy/Initiatives
<u>National Climate Change Policy (NCCP) (2009)</u> - NCCP is based on the following principles: (1) development on a sustainable path, (2) conservation of environment and natural resources, (3) coordinated implementation, (4) effective participation, and (5) common but differentiated responsibilities and respective capabilities. **<u>New Economic Model (NEM) and Transformation Programme (2010)</u>** - NEM is executed to transform Malaysia into a high-income country by year 2020. - The mission of NEM is to embrace development that is sustainable both in terms of economy and environment. **<u>National Renewable Energy Policy and Action Plan (NREPAP) (2010)</u>** - NREPAP was introduced to proliferate the utilization of indigenous RE resources through effective management of RE resources and human capital, and active institutional involvement. - The five thrust of NREPAP are (1) introduce appropriate regulatory framework, (2) provide conducive environments for RE businesses, (3) intensify human capital development, (4) enhance RE research and development and design, and (5) implement an RE advocacy programme. - Two important nexus related to NREPAP are Renewable Energy Act legislated in 2011 and the Sustainable Energy Development Authority (SEDA). - SEDA is given the mandate to implement the Feed-in Tariff mechanism (FiT) in the country. The initial impetus of FiT started when Malaysian Building Integrated Photovoltaic Project (MBIPV) (2005) project was introduced. **<u>Tenth Malaysia Plan (2011-2015)</u>** - The Tenth Malaysia Plan focuses on advancing the utilization of RE in the country. The climate resilient strategy was two-dimensional: firstly, adjustment techniques to shield the country from the effects of environmental change; and also, relief methodologies to diminish GHG outflows. - The Renewable Energy Act 2011 assisted the Feed-in Tariff (FiT) implementation. Under the Act, Sustainable Energy Development Authority (SEDA) was set up to spearhead the FiT projects. - In 2013, Increase EE by imposing Minimum Energy Performance Standards (MEPS) for domestic appliances - Entry Point Projects (EPP) to increasing the solar power capacity and to tap hydroelectricity was executed. - To reduce emission from the transport sector two major projects were implemented, Kuala Lumpur Light Rail Transit (LRT) and Mass Rapid Transit (MRT) system. - The implementation of the Reduce, Reuse, Recycle (3R) programme for better waste management. - In 2011, National Steering Committee on REDD+* (NSCREDD) was initiated to structure directions and strategies for REDD+ establishment. *REED+: Reducing Emissions from Deforestation and Forest Degradation, and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks in Developing Countries **<u>Eleventh Malaysia Plan (2016-2020)</u>** - The pursuit of environmental protection is at a greater scale under the Eleventh Malaysia Plan, which aims to foster green growth for sustainability and resilience. - The aim is to be achieved through a framework that takes into account resource-efficiency, low-carbon and social-inclusion for every aspect of investment incurred to develop the country. RE and EE is definitely the core of the framework for long-term sustainability. - There are four key areas

Table 2.3 : Summary of environmental policies and initiatives in Malaysia-continue

Policy/Initiatives
National Agro-Food Policy (NAFP) 2011
- NAFP is a 10-year policy plan that effectively replaced the National Agriculture policy on 28 September 2011. Among the main objectives of the policy are to (1) ensure adequate food supply and food safety, (2) develop the agro-food industry into a competitive and sustainable industry, and (3) increase the income level of agricultural entrepreneurs. The new policy emphasizes on sustainable agriculture development as the main key thrust.
- The Malaysian Organic Scheme (MyOrganic) (2007): Certification for organic farms.
- Malaysian Good Agricultural Practices (MyGAP) (2013): Certification scheme for agricultural, aquaculture and livestock sector (i.e., the product should be of good quality and save and aspect of environment is taken into consideration).
National Policy on Biological Diversity (NPBD) (2016-2015)
- The first NPBD was formulated in 1998. However, increasing population and economic activity over the years have imposed a huge threat to the biodiversity.
- In 2016, NPBD (2016-2025) was introduced with a better biodiversity protection framework and a detail action plan. The five revised principles are (1) biological diversity is national heritage-managed wisely, (2) precautionary-measures to significantly minimize loss of biodiversity, (3) shared responsibility-conservation and sustainability of biodiversity is a shred responsibility, (4) participatory-planning and management of biodiversity in participatory manner, and (5) good governance-transparency in biodiversity conservation.

Note: The information is based on author's own readings and collection of information from various resources. Information under the Malaysia Plan is according to the initiative that were conducted during the tenure of the plan rather that the proposed initiatives during the tenure. Initiatives that had incomplete information (i.e., responsible ministry or agency) were placed according to the most related policy or Malaysia Plan.

Source: Compiled from various reports and articles (Aldover & Hun-Yang, 2010; EPU, 2006, 2011b; GOM, UNDP, & GEF, 2011; a. a. Hezri & Nordin, 2006; Hezri & Hasan, 2004; Jaafar, Kheng, & Kamaruddin, 2003; KeTTHA, 2008; Malaysia, 1986b, 1991, 1996b, 2001, 1976, 1981; MOA, 2013; MOSTI, 2002; NRE, 2009, 2011, 2015, 2016; Oh, Pang, & Chua, 2010; Samuel, Agamuthu, & Hashim, 2013)

2.4.2 Financial Resources

Sound financial resources and mechanism also drive EI (Cuerva et al., 2014; del Río, 2009; Painuly, Park, Lee, & Noh, 2003). Accordingly, lack of financial resources constrains innovation and dampen creativity (Camisón-Zornoza, Lapiedra-Alcamí, Segarra-Ciprés, & Boronat-Navarro, 2004; Ghisetti & Rennings, 2014; Savignac, 2008). Asymmetric information, uncertainty and risk that is prevalent in undertaking innovative activity, automatically hinders the financing of these activities (Eric, Beraha, & Djuricin, 2011; Hall, 2010; Hewitt-Dundas, 2006; Mohnen, Palm, Van Der Loeff, & Tiwari, 2008). On that note, financing EIs specifically will encounter greater scrutiny due to higher technical and commercial risk, as this area of innovation is booming and transforming rapidly (Aghion, Veugelers, & Serre, 2009).

However, financial resources is not found to be the critical determinant of EI (Xia, Chen, & Zheng, 2015) but seems to play an important role in complementing other determinants of EI. Scholars have placed greater emphasis on the relationship between EI and firms business/financial performance (Cheng et al., 2014; Przychodzen & Przychodzen, 2015; Xia et al., 2015), while there is also an urgent need to research on specific drivers of eco-financing[2], as limited studies are available.

2.4.3 Environmental Strategy

Complex environmental issues which are rapidly increasing and have challenged firms to formulate superior environmental strategies to sustain their competitive advantage. Environmental strategy is referred to as 'a strategy that manages the interface between its business and the natural environment' (Aragón-Correa & Sharma, 2003, p. 71).

[2] Financing projects that are specifically related to eco-innovation.

Environmental strategies fall between two different continuum, environmental reactivity and environmental proactivity. Environmental reactivity refers to firms implementing mere initiatives just to meet environmental regulatory requirements. Meanwhile, the latter refers to firms dwelling with extensive voluntary events to protect the natural environment (González-Benito & González-Benito, 2006).

Every firm has their own technique in formulating their environmental strategy, based upon their unique resource endowment. However, resource-based view has two distinct capabilities that is essential for firms to acquire in formulating effective environmental strategies, which are shared vision and strategic proactivity (Aragón-Correa, Hurtado-Torres, Sharma, & García-Morales, 2008).

1. Shared vision

   In order to have organizational capability of shared vision, firms need to entail all the members in the organization to envelope same values and belief, that are geared towards achieving organization objectives and mission. In addition, the commitment and involvement of managers from every level is essential to materialize this shared vision (Oswald, Mossholder, & Harris, 1994).

2. Strategic proactivity

   Strategic proactivity takes place when firms are able to have a distinct understanding on the changes that are taking place surrounding their business environment. At the same time, they are able to integrate the changes into their existing unique business strategy. The changes need to be deliberately fit into their existing strategic policies (i.e., entrepreneurial, engineering and administrative routines), so that the new initiatives do not conflict, with other aspects of the business (Aragón-Correa et al., 2008; Aragón-Correa, 1998). Firms that are strategically proactive have a greater tendency to quickly adapt to changes and contribute to technological advancement (Aragón-Correa, 1998).

Growing environmental issues either forcefully or voluntarily caused firms to incorporate environmental issues into their business strategy. This incorporation poses a huge challenge to firms due to uncertain environment coupled with the unpredictable nature of innovation, where technology is changing rapidly (Milliman & Prince, 1989). The concept of corporate environmentalism projects the path of the dependence process on the creation and incorporation of the environmental strategies business strategies (Banerjee, Lyer, & Kashyap, 2003; Banerjee, 2001, 2002). Corporate environmentalism refers to the amalgamation of environmental issues in the decision-making of a firm's business. Corporate environmentalism, according to Banerjee, encapsulates environmental orientation (EO) and environmental strategy.

Environmental orientation (EO) is the identification of environmental threats that firms pose towards the environment due to their business operations and the solutions to these problems. EO is a convergence of two sub-clusters. First, internal EO that focuses on the firm's internal culture, which is the values and ethics, is involved in shaping commitment towards the environment. Second, external EO emphasizes on the managers' view pertaining external stakeholders and their responses on the interest. The firm's EO is translated into the firm's mission and statement of vision. The firm's EO transpires into the working philosophy of the entire organization (Chamorro & Bañegil, 2006), which coordinates the relevant capabilities for strategy formulation. Additionally, the internal economy in terms of the organizational system, formalization and centralization also prompts the adoption of these strategies (Fraj-andrés *et al*., 2009). There is a complex integration between the change in philosophy, capabilities and systems behind an environmental strategy. Since the inception of the environmental management systems (EMS), firms have been adopting them as system provides the structure and base required for the implementation of the environmental actions (González-Benito & González-Benito, 2006).

The formulated and designed strategies will be incorporated into the organization's strategic business plan at four different stages, namely at enterprise, corporate, business and functional levels (Banerjee et al., 2003; Schendel & Hofer, 1979) (see Table 2.4).

Table 2.4 : Four levels of strategic business plan

Level	**Strategy**	**Details**
1	Enterprise	Deals with a firm's fundamental mission and its contribution towards the society.
2	Corporate	Focuses on the types of business that a firm should envelope to materialize the strategy targeted by the enterprise.
3	Business	Working on a firm's competitive advantage through efficient resource allocation, product differentiation and/or focusing on niche market.
4	Functional	Engage in establishing operating procedures for different business/organizational functions such as advertising, sales, research and development and others.

Source: Four different levels of strategies (Banerjee et al., 2003; Schendel & Hofer, 1979)

Transition from short-term strategies to solving environmental issues to long-term proactive environmental strategies has certainly taken place due to exponentially growing global environmental concern. Many studies have primarily focused on proactive environmental strategy (Aragón-Correa et al., 2008). According to Hart (1995) in his work on natural resource based view (NRBV), a proactive environmental strategy is essential for firms sustainable competitive advantage.

Therefore, firms' proactive environmental strategy has been instrumental in inducing EI (Aragón-Correa et al., 2008; Aragón-Correa, 1998; Gerstlberger et al., 2014; Wagner, 2005) as part of their competitive mission. A study by Gerstlberger, Praest Knudsen, & Stampe (2014) employed the European Manufacturing data from Denmark that studied 335 firms, to measure the relationship between sustainable environmental strategy and product innovation. The results revealed that market-related aspects of environmental strategy (i.e. cost of R&D and user friendliness) have a positive influence on product innovation. The study further recommended that a detailed and specify environmental strategy entails EI, which has the potential to promote sales and profit growth (Menguc, Auh, & Ozanne, 2009).

Several issues have emerged while reviewing environmental strategy literature. First, the definitions of environmental strategy by Aragón-Correa & Sharma (2003) do not provide a clear understanding of environmental strategy. Researches have been using different aspects in measuring environmental strategy and frequently included Environmental Management Systems (EMS) as a measure of environmental strategy, whereby the EMS is part of the organizational eco-innovation. Thus, the inability to measure the direct link between environmental strategy and eco-innovation. Several researches have included and highlighted some aspects of environmental strategy, which seem to be more suitable to measure environmental strategy. The aspects are as following:

1. To invigorate managerial and technical skills among employees and management (Aragón-Correa, 1998; Mårtensson & Westerberg, 2014).
2. To increase top management support (i.e. important in shaping organizational value) (Menguc et al., 2009).
3. To promote team decision making, as it is more effective (Torre-Ruiz, Aragón-Correa, & Martín-Tapia, 2015).
4. To realign the physical capital (Lucas, 2009).
5. To deal with issues pertaining to consumer sensitivity (Menguc et al., 2009).
6. The mechanics that is required to coordinate and control these strategies (Epstein & Roy, 2007).

Developing a sound environmental strategy calls for changes in the firm's routines and operations (Christmann, 2000). Therefore, the measurement of environmental strategy needs to look into the ways and mechanisms to incorporate the resources.

The second issue is pertaining reference to the dynamic capabilities view. Teece (2007) expressed that firm's ability to constantly "create, extend, upgrade, protect, and keep the enterprise's unique asset base relevant" complements that the development of critical capabilities is important for firms to sustain their competitive advantage. Thus, it can be conferred that environmental strategy is the central agent that constantly integrate firms changing routines and operations due to growing environmental issues. Therefore, firms can quickly reconfigure and combine environmental resources such as skills and environmental knowledge to promote EI (Hart, 1995).

EI drivers, therefore, do not directly influence EI but has an indirect effect on EI through environmental strategy. This is further supported by studies that have linked stakeholder pressure to environmental strategy. Stakeholders is referred as "any group or individual who can affect or is affected by the achievement of the organization's objectives" (Freeman, 1984, p. 46). The pressure from the stakeholders influence firms to embark on sound environmental strategies (Abreu, 2009; Betts, Wiengarten, & Tadisina, 2015; Darnall, Henriques, & Sadorsky, 2010; Henriques & Sadorsky, 1999). These stakeholders are from both internal stakeholders, i.e. management and employees (Darnall, Henriques, & Sadorsky, 2010), and external stakeholders, i.e. customers (domestic and international) and regulators (Betts et al., 2015; Calza, Profumo, & Tutore, 2014). These internal and external stakeholders are in fact the drivers of eco-innovation, i.e. consumer pressure, environmental regulation, employee with green skills and others.

So far, however, there has been little discussion on linking capability of other EI determinants, environmental strategy and EI. Majority of studies in the area of proactive environmental strategy paid greater attention to the determinants (Betts, Wiengarten, & Tadisina, 2015; Murillo-Luna, Garcés-Ayerbe, & Rivera-Torres, 2011; Zhu & Sarkis, 2007) rather than the outcome (i.e., EI). Firms with a proactive environmental strategy is seen contributing to greater EI (Mårtensson & Westerberg, 2014; Menguc et al., 2009). Nonetheless, every firm moves along a unique managerial path to tackle their environmental issues as they are constrained by different resources and market conditions. Therefore, the understanding of the environmental strategy role to coordinate and reconfigure resources for EI is important due to the vigorously growing environmental issues.

2.4.4 Environmental Collaboration

Currently, there is limited comprehensive definition for environmental collaboration. Since, there is a growing and gripping literature on environmental management within the supply chain network (Simpson, Power, & Samson, 2007; van Hoof & Thiell, 2014; Zhu, Sarkis, & Lai, 2008), and researchers have developed a collaboration index to measure the supply chain collaborations (Simatupang & Sridharan, 2002, 2005), this sphere of knowledge is used to derive the preliminary broad definition of environmental collaboration. Three integral elements (i.e., sharing of information, making joint decisions, and sharing benefits) are used to form this definition. Therefore, environmental collaboration occurs when more than two organizations join forces to share information, make joint decision and share their best practices to mitigate adverse environmental effects of human activity towards the environment. Firms generally collaborates with various external stakeholders such as the government agencies, suppliers, consumer, competitor, research institutes, universities, NGO's and others to promote innovation.

Recently, collaboration and networking as the determinant of EI has gained a lot of attention and acknowledgement (Cainelli, De Marchi, & Grandinetti, 2015; Kohl, Orth, Riebartsch, Galeitzke, & Cap, 2015; Störmer, 2008). Studies executed using substantial manufacturing data of firms in staunch innovation based countries such as Germany (Horbach et al., 2012; Wagner, 2007), Spain (De Marchi, 2012) and an aggregate of 27 European countries (Triguero et al., 2013) found collaboration to positively influence EI. The collaboration for EI was deemed more important as compared to innovation in general (De Marchi, 2012) and firms that collaborate are found to be more economically successful. Despite large literature and empirical findings supporting the link between collaboration and EI, a handful of studies nullify the positive relationship between collaboration and EI (Bönte & Dienes, 2013; Cuerva et al., 2014).

Researchers have recognized that collaboration and networking has the capability to diversify risk and minimizes uncertainty associated to innovation (Cainelli et al., 2015; Kogut, 1991), as it is still new and open to criticism (de Medeiros, Ribeiro, & Cortimiglia, 2014). While this collaborations reduces risk, new opportunities and ideas are also attained (Tether, Mina, Consoli, & Gagliardi, 2005).

Moreover, collaboration and networking allow firms to access essential resources through dynamic interactions, which can be timely and costly to obtain if there were no such alliance between firms (Lavie, 2006). The complex nature of EI as compared to non-EI calls for sophisticated collaboration especially for high-value R&D results (De Marchi, 2012). This is in tandem with the collaboration theory, which entails innovation in collective problem solving especially for intricate issues (Heimeriks & Duysters, 2007; Powell, Koput, & Smith-Doerr, 1996). Finally, the tacit flow of technological knowledge that occurs during these alliances further enhances the technology capability of a firm (Doz & Shuen, 1988). This additional spill over enables the firms to target for dynamic efficiency when developing EI which is more important based on the current escalating pollution levels (del Río, 2009).

Collaboration is a supply side factor that trigger firms' EI initiatives (Triguero et al., 2013). Collaborations that transpires specifically for solving global environmental problems has the capability to encourage extensive level of resource exchange, sharing of expertise (Rasi, Abdekhodaee, & Nagarajah, 2010) and improved competitiveness (van Kleef & Roome, 2007) , which makes EI more meaningful. Hall et al. (2013) deployed an inductive route to explore the role of stakeholder collaboration for EI in seaports and freight industry. Their multiple case studies revealed that collaboration achieved through dynamic yet complex stakeholder interactions is central to their EI initiatives. This finding is in congruence with van Hoof & Thiell (2014), which empirically examined collaboration in the sustainable supply management realm. Their investigative further highlighted the role of collaboration in nurturing employee skills and top management involvement to materialize organizations sustainable agenda. Both these studies revealed that dynamic interaction that occurs during collaboration, indirectly nurture employee's green skills and increases firms top management commitment. These additional capabilities are required to mechanize EI activities.

Collaboration is important to build green skills among employees (Evans & Stroud, 2016). These skilled and knowledgeable workers reciprocates by integrating and facilitating the output from collaboration for effective innovation (Leiponen, 2005). Therefore, there is an indirect link between collaboration and EI, which requires further attention from researchers.

2.4.5 Market Pressure

According to institutional theory, environmental adjustment take places depending on normative (i.e., consumer), mimetic (i.e., competitor) and coercive (i.e., regulation) pressure (Dimaggio & Powell, 1983). Market and non-market pressure are both external source of factors that stimulate initiatives to eco-innovate (del Río et al., 2016). Market pressure mainly stems from competition and consumer, while non-market pressure is from environmental NGOs or pressure groups.

Pressure stemming from consumers is regarded as critical element to be considered when dealing with environmental issues (Henriques & Sadorsky, 1996). Reinstaller (2005) deployed a case study approach to capture the social process embodied along the EI development that took place in the pulp and paper industry during the 1990s in Sweden and the U.S. The study found that change in consumer behavior imposed a considerable amount of pressure on the choice of technology employed by firms. Another research carried out in the pulp and paper industry by Popp et al. (2011), utilized paten data to explore the sustainable evolution in engaging with competing bleaching technology also found that consumer pressure motivated the change.

Increasing green awareness and education amongst consumer is the prime reason that inflated the pressure among consumer to demand for greener products. Studies found that consumers with higher education background have a greater tendency to shift to green products (Yalabik & Fairchild, 2011). However, pressure from consumers is still evolving (Zhu, Sarkis, & Geng, 2005) especially for developing countries, due to shoddy environmental awareness. In contrast to external pressure, internal pressure from shareholders, top management and employees has the capability to positively effect EI (Betts et al., 2015; Murillo-Luna et al., 2011). The pressure toward firms to eco-innovate is not only from local consumers but also from overseas consumer (Christmann & Taylor, 2001).

Using a vigorous theoretical and mathematical modeling standpoint, several studies provided a strong foundation that competition greatly induces EIs (Arora & Gangopadhyay, 1995; Bagnoli & Watts, 2003). The absence of this competition can be detrimental to the environment (Yalabik & Fairchild, 2011). Competition pressure to innovate can arise from both local and foreign firms (Liu, Hodgkinson, & Chuang, 2014). The importance of competition to induce innovation can be observed in the transformation that occurred in the energy sector during the 1970s. The introduction of new renewable energy technologies, liberalized energy policies and national environmental innovation systems over the years have intensified the competition in the utility market (Jacobsson & Bergek, 2004; Jacobsson & Johnson, 2000).

Since then, various types of renewable energy technology, such as solar, wind power and biomass have made their mark in transforming the landscape of sustainable energy market and attracted new firms into the area. Nesta et al. (2014) empirically investigated the relationship between market competition and new renewable technology. Their study employed patent data as the proxy for renewable energy and product market regulation (PMR) index as proxy for market competition. PMR index was developed at OECD; it takes value between 0 to 6, where higher values are characterized by lack of competition. Based on the results, invention in renewable energy appears in market that is more competitive. Another study using binary discrete choice model analyses by Ziegler & Rennings (2004), found pressure from competition to positively effect EI. This finding is consistent with several other literature that highlighted the importance of competition on EI (Dereli, 2015; Shrivastava, 1995; Zhu & Sarkis, 2007).

Pressure from NGOs is influential in shaping societal green behavior (Vogel, 2000), which transpires into sound EI initiatives. NGOs are able to exert a considerable amount of pressure to locate economy activities on the environmentally sustainable path by influencing the business community and government in giving greater care towards the environment. Meanwhile, NGOs constitutes to various international environmental treaties that allows for powerful negotiation between domestic and international parties to curb environmental problems. In addition to that, NGOs are able to take drastic steps by coordinating boycotts on harmful products, or lobbying powerful interest groups to achieve their environmental agenda. NGOs have the capability in doing so due to the availability of all the cutting-edge skills, pool of solid information, international networking, and professional staff that are from various world-renowned organizations (Betsill & Corell, 2001; Raustiala, 1997). Based on the literature, this study construes that with a powerful background and extensive support, NGOs are game changers in the sustainable environment arena. Their implication towards EI is not direct but path dependent.

Studies have pointed out that external pressure need to be complemented with binding regulation for effective innovative outcomes (Kerr & Newell, 2003). Most of the studies that engage in examining the relationship between external pressure and eco-innovation often take into consideration the role by regulation in elevating this pressure. External pressure performs at its best when this pressure results towards an impactful environmental regulations (Kleindorfer, Singhal, & Wassenhove, 2005). Therefore, environmental policies should not only focus on the direct impact of regulation on firms to eco-innovate, but look into mechanism to disseminate pertinent environmental information to society to build the sustainable behavior among consumers, which later escalates the pressure that they inflict on firms to foster EIs.

2.4.6 Export Behavior

Export oriented firms are proven to be more innovative (Horbach, 2014). Domestic firms that seek to remain internationally competitive, by sustaining and expanding their export contacts/clients abides to environmental regulations and standards set by their foreign counterparts (Brunnermeier & Cohen, 2003). This behavioral change pressures them to invest into EI R&D (Scott, 1997). Moreover, critics argue that export oriented firms in developing countries are more attentive to foreign environmental regulations as compared to their domestic environmental regulations (Abrahamson & Rosenkopf, 1993; Christmann & Taylor, 2001). A study on multinational enterprises and domestic firms in China was conducted to find whether domestic firms, which export largely to developed countries, have greater tendency to comply with environmental regulation. The results revealed that domestic firms that largely exports have positive and significant relationship with environmental compliance (Christmann & Taylor, 2001). Another study on seven OECD countries to determine the relationship between environmental policy and innovations found that firms which are involved in the global market, have a greater tendency to raise their environmental performance (Lanoie et al., 2011).

During the encounters of international trade, firms experienced a certain behavioral change. The active communications with foreign competitors and self-observation of exporting firms on foreign EI caused knowledge spillovers. This in return, encouraged exporting firms to increase their competitive edge by investing in EIs, which exhilarates environmental performance (Perkins & Neumayer, 2008). Thus, the increasing competition and export intensity boost the cross-border transmission of cleaner production practices, and further pressures the firms to be more environmentally friendly by strictly monitoring their environmental performance (Vogel, 2000).

According to prior studies, undisputedly a far-reaching determinant of innovation is demand-pull (Cleff & Rennings, 1999; Gunther & Janz, 1999; Peters et al., 2012), i.e. the market contains a considerable of power to influence innovation initiatives. Thus, export markets being an international determinant of EI is a strong demand-pull trigger. There have been several studies in the literature reporting positive impact of export on EI (Ghisetti, Marzucchi, & Montresor, 2015b; Horbach, 2008).

Besides huge acknowledgement given to export oriented firms for churning greater innovation, there are considerable amount of studies that proved export is not a significant determinant of EI (Cainelli, Mazzanti, & Montresor, 2012; Rehfeld, Rennings, & Ziegler, 2007; Ziegler & Rennings, 2004). Two possible reasons can be brought forward for these contradicting results. First, developed countries are the geographical scope for most of this research such as German and Spain. These countries a far technologically advanced as compared to other countries and have stringent environmental standards. Therefore, there is a higher possibility that these countries are exporting premium environmentally friendly product and services to meet higher environmental standards as compared to the requirement of the foreign counterparts require. This could be the main reason why export in not a significant determinant of EI for these countries.

The second issue focuses on a large portion of these studies uses a dummy variable as a proxy for export, which takes the value of one if a firm is exporting in a particular year. Such proxy is unable to gauge solid information on how export market influences their eco-innovation behavior. This can be another ground for the results of these studies to be questionable.

Inferences made from large strand of studies suggested that export is not a factor describing the decision to eco-innovate. In fact, firms exporting behavior provides knowledge and benchmarking information on the current environmental initiatives and advancements, so that firms can strategize. In addition, this is only important for firms that intend to be active and remain competitive in the international markets. Therefore, rather than finding the direct link between export and EI, it might be more relevant to explore its relationship with the strategy that the firm employs to remain competitive.

2.4.7 Green Skills

Deriving a comprehensive and definitive definition of green skills is not only impossible but also rather impractical at many levels. Research by Martinez-Fernandez & Hinojosa (2010) that examined an extensive literature on the impact of climate change on green job and skills development argued that the frame of green skills changes according to the nature of industry and at every level of production sophistication. Green skills, according to the research is not a new spectrum but a link between a wide array of existing skills and new skills that help to mitigate adverse environmental effects of human activity towards the environment, or skills that provide an improved technique to manage climate change conditions. This broad definition of green skills is widely used and emphasized in many other green jobs related research (Deschenes, 2015; Dierdorff et al., 2009).

The importance of green skills to create/adopt innovation has been widely recognized (Strietska-llina, Hofmann, Haro, & Jeon, 2011). Innovation theories have long highlighted the relevance of technological capabilities, which consists of physical and knowledge capital stock to promote innovation (Rosenberg, 1976). Superior innovation depends on the expansion and quality of these capabilities. Provision of trainings specifically for innovation activities positively influence the initiation EI, as discussed by Cainelli et al. (2012). In support to the earlier research, several other studies have also acknowledged the requirement of specific and advanced level of skills for firms to embrace EI (Corral, 2002; Horbach, 2014). In contrary, a number of studies stated that skills and training for the purpose of EI is insignificant (Cainelli et al., 2015; Horbach, 2008).

Findings that recognize or contradicts the positive impact of green skills on eco-innovation, however, may provide reasons on the perspectives prior a rendering a conclusion on the subject matter. One fundamental issue that needs to be understood is that there is no clear-cut evidence that green skills directly affect EI. The construction industry, for example, is a highly complex industry that requires a solid coordination of resources and material within the completion period of the project. Thus, a highly proficient project manager is vital for a construction project to be successful (Belassi & Tukel, 1996). Green revolution over the years has transform the construction landscape with green building index, which has placed greater emphasize on green building construction. This in return has escalated the demand for project managers with green construction skills with sustainability aspect as a principal priority (Russell, Jaselskis, & Lawrence, 1997; Hwang & Ng, 2013). The contribution of these project managers is multilayered, stemming from material selection, human resource management, energy conservation and others (Hwang & Ng, 2013). Thus, it is evident that there is no strong direct link between green skills and EI. Therefore, the positioning of green skills variable within the EI framework is important before any analysis is conducted.

Most of these studies did not use a comprehensive tool to measure green skills but depend on the share of trained employees over total employment, quality of skilled personnel or a survey database on community innovation. Measures that place greater emphasis on green content of training is worthy of extra attention to obtain promising findings.

Green skills may be viewed in light of imperative resources to understand its strategic positioning within a firm's eco-innovation framework. As technology push factors are fundamental for eco-innovation (Cleff & Rennings, 1999; Horbach, 2008), green skills are critical resources that enhance firm's internal conditions to promote EI (del Río González, 2009), and coordinating the latest technological knowledge to facilitate the in-house process of creation or adoption of EI (del Rio, 2004). Therefore green skill resources activates technology push (Cuerva et al., 2014).

Policies that promotes the acquisition of green skills are powerful drivers of EIs (Cainelli et al., 2012). Both internal and external trainings has the capability to uplift a firm's innovation performance (Gupta & Singhal, 1993; Laursen & Foss, 2003). The adaptation to new working skills is part of the dynamic transition to an environmentally sound manufacturing. The firms that want to be ahead of their competitors in terms of successful technological advancement need to continuously invest in superior trainings for their workers (Altmann, Rundquist, & Florén, 2003).

The inclusion of green skills in the EI framework is crucial as it invigorates other technological competencies within the firm. The provision of a perfect mix of internal and external trainings would not only proliferate firms environmental performance but also enable the firms to obtain competitive advantage against their rivals. Thus, the understanding of multilayered functioning and strategic positioning of green skills in EI framework needs to be carefully tackled.

2.4.8 Environmental Knowledge

Since the commencement of resource-based view, a lot of attention has been paid towards firms unique internal resources and competencies (Barney, 1991; Wernerfelt, 1984), firms that have greater internal knowledge resources are expected to generate better and effective ideas in ensuing with new innovations. Firms that are able to accumulate specific knowledge about their industry or their niche area of production, are prone to undertake a more radical innovation (Zhou & Li, 2012). In a similar vein, the accomplishment of EI depends largely on environmental knowledge resources. Environmental knowledge specifically for the industry can be referred as the technological knowledge. This is defined as the knowledge for planning and refining technological process and structures, which may alter the full stream of physical sustainability objects such as the production system to serve a more environmentally friendly purpose (Shin, Curtis, Huisingh, & Zwetsloot, 2008).

A handful of investigation was reviewed to convince the need for environmental knowledge to promote EI. Epicoco et al. (2014) in their study on dynamics of scientific knowledge in green chemistry expressed the importance of environmental knowledge in promoting sustainable EI in the chemical industry. Environmental knowledge is reckoned to accentuate firms competitive advantage based on their eco-innovative capacity (Barney, 1991; Ghisetti et al., 2013). In a similar vein, Porter & Linde (1995b) pointed out that well informed managers and regulators encourage eco-innovation. Knowledge breadth and depth that firms acquire, moreover, has a great implication on firms innovativeness as well (Ghisetti et al., 2015a; Zhou & Li, 2012). Finally, there is always a colossal amount of uncertainty and risk involved in undertaking fresh innovation projects; thus, firms depend on routinized innovation[3]. Hence, to accelerate the EI activity[4] it is highly essential for the firms to build their knowledge stock (Bauernschuster, Falck, & Heblich, 2008).

There is sparse but prominent findings that shows environmental knowledge has a significant positive impact on EI (Lenox & King, 2004; Shin et al., 2008; Simpson,

[3] Innovation that is not directly executed but it is slowly developed relying on existing knowledge, experience and routines that the firms have (Bauernschuster et al., 2008).
[4] Eco-innovation activity refers to the entire process that is involved before EI is produced.

2012; Zhou & Li, 2012). While some researchers are acquainted with examining the direct linkage between environmental research and EI, others have taken a set forward by investigating the mediating role of environmental knowledge. Their inquiry acknowledged that environmental knowledge mediates the relationship between determinants of EI and firm's technical innovation performance (Chen & Huang, 2009; Simpson, 2012).

Over the years, there has been a growing literature on the importance of environmental knowledge and information created outside the firm through external sources. This is because, environmental knowledge is embodied in the technology and R&D material/services obtained from external sources. EI activities were found to demand greater external sources of knowledge as compared to innovation in general (Horbach et al., 2013). In exploring how innovation in energy technology can be influenced by the flow of international knowledge, Verdolini & Galeotti (2011) revealed that increasing stock of international knowledge in the domestic market contributes to a greater probability of innovation.

External sources of environmental knowledge is vital, however, firms must have a well-developed internal "absorptive capacity" in order to effectively acquire and use this knowledge (Cainelli et al., 2015). According to Cohen & Levinthal (1990), to apply an understanding of its prior related knowledge to the external knowledge is necessary. This is because prior knowledge builds the ability to acknowledge, monitor, incorporate and employ new knowledge for commercial benefits. The amalgamation of these abilities is referred as the firms "absorptive capacity". Therefore, environmental knowledge utilized by firms to eco-innovate is an assimilation of both external and internal resources.

With the absorptive capacity getting into the context, undoubtedly, knowledge management capability begins to play a central role once the acquisition of environmental knowledge has taken place. The successful utilization of this knowledge depends on how it is managed, shared, improved and expanded within the organization to generate creation and innovative outcomes (Chen & Huang, 2009).

For developing countries, technologies are not directly adopted from foreign countries (Popp, 2006a) . Local firms need to have a comprehensive knowledge of their domestic market and understand the relevance of the adoption of this foreign technology. Moreover, local firms need to understand on how to assimilate this foreign technology into their R&D that will in return add value to their production. This clearly shows that in developing countries, regulators need to integrate the knowledge of this foreign adaptive R&D into their environmental policies. Therefore the incorporation of both knowledge resources and management is required to ensure effective EI activities ensued. A continuous information flow is recommended; as to constantly update the stock of knowledge available and to move away from routinized innovation. An important point to be noted is that there no collective tool being used to measure environmental innovation which takes into consideration environmental resources, its internal absorptive capacity and the dispersion of this knowledge.

2.5 Preliminary Hypothesis and Conceptual Framework

Preliminary hypothesis is derived from empirical evidence provided by prior studies in section 2.4. In the process setting of up the preliminary hypothesis, attention was paid to the direct relationship that transpires between the determinants and EI. There were two reasons for doing so. First, the selection of these drivers was according to extensive study conducted by Del Rio especially in the aspect of exploring firms EI determinants (del Río, 2009; del Río et al., 2016). Therefore, at the initial stage, sufficient literature and evidence was gathered to validate whether direct relationship exist between the determinants, and the EI proposed by Del Rio is positive or negative. Second, the intention was to develop a general EI framework that will not be biased toward developed countries scenario as most of the literature is dependent on studies from there.

While assessing the existence of direct relationship, the strength of the hypothesis was also evaluated. The strength was seen in terms of literature and empirical evidence supporting the existence of the direct relationship. Two variables that have proven to have strong direct relationship are environmental regulation and regulation stringency; while rest of the variables exhibit the tendency to have an indirect relationship. The preliminary hypothesis is summarized in Table 2.5. Based on the argument established in section 2.4, Figure 2.4 presents the preliminary conceptual framework of the study.

Table 2.5 : Preliminary hypothesis

Variable	Relationship	Hypothesis	Strength of the Hypothesis
Environmental strategy	Positive (Gerstlberger et al., 2014)	*Hypothesis 4: Environmental strategy positively influence eco-innovation*	Available empirical and literature evidence. Greater chances of being a dominant mediator between eco-drivers and eco-innovation
Environmental collaboration	Positive (De Marchi, 2012; Triguero et al., 2013)	*Hypothesis 5: Environmental collaboration positively influence eco-innovation*	Available empirical and literature evidence. Might exhibit an indirect relationship.
Green skills	Positive (Cainelli et al., 2012)	*Hypothesis 8: Green skills positively influence eco-innovation*	Available empirical and literature evidence. Might exhibit an indirect relationship.
Environmental knowledge	Positive (Shin et al., 2008; Zhou & Li, 2012)	*Hypothesis 9: Environmental knowledge positively influence eco-innovation*	Available empirical and literature evidence. Might exhibit an indirect relationship.
Financial resources	Positive (Painuly et al., 2003)	*Hypothesis 3: Financial resources positively influence eco-innovation*	Available empirical and literature evidence. Not a critical driver.
Market pressure	Positive (Nesta et al., 2014; Ziegler & Rennings, 2004)	*Hypothesis 6: Market pressure positively influence eco-innovation*	Available empirical and literature evidence. Might exhibit an indirect relationship.
Export Behavior	Positive (Christmann & Taylor, 2001; Lanoie et al., 2011)	*Hypothesis 7: Export behavior positively influence eco-innovation*	Available empirical and literature evidence. Might exhibit an indirect relationship.
Environmental regulation	Positive (Lee et al., 2011; Naoilly, 2012)	*Hypothesis 1: Environmental regulation positively influence eco-innovation*	Strong supporting literature and empirical evidence. Direct relationship should be stronger for developing countries.
Regulation stringency	Positive (Johnstone et al., 2012; Kerr & Newell, 2003)	*Hypothesis 2: Regulation stringency positively influence eco-innovation*	Strong supporting literature and empirical evidence. Direct relationship should be stronger for developing countries.

Note: Relationship = Variable relationship with eco-innovation

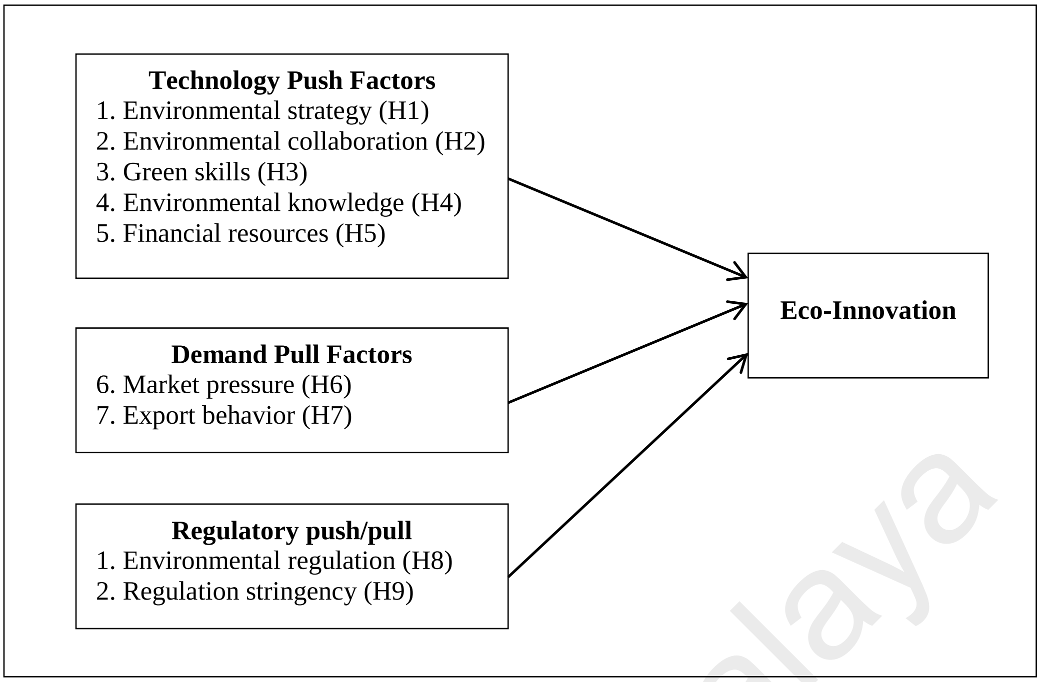

Figure 2.4 : Preliminary conceptual framework

2.6 Summary

The aim of this chapter was to develop the preliminary hypothesis (see Table 2.5) and conceptual framework (Figure 2.4). A thorough literature review was executed to determine the direct and indirect relationship that the determinants of EI could postulate. Attention was given to the direct relationship in setting up the preliminary hypothesis, and the conceptual framework was loosely developed so that it provided the basis for the next stage, which is the structured interview.

From the literature is was understood that theories stemming from the field of environmental economics, innovations economics and management was important to structure the eco-innovation framework (i.e., the path model). Major theories considered for this study are theory of induced innovation, resource-based theory evolutionary economic theory and stakeholder theory. The literature also provided evidence that all the eco-innovation drivers are not directly linked to eco-innovation. For example, determinants like environmental collaboration, environmental knowledge, green skills and export behavior exhibited greater tendency to influence the environmental strategy as compared to eco-innovation. Meanwhile, environmental strategy and environmental regulation have proven to directly influence eco-innovation. Therefore, based on the literature review the study expects to find a more integrated model that brings to gather direct and indirect linkages between the determinants of eco-innovation in order to stimulate eco-innovation within the firms.

CHAPTER 3 : OVERVIEW OF THE CHEMICAL MANUFACTURING INDUSTRY IN MALAYSIA GENERALLY AND SELANGOR SPECIFICALLY

3.1 Introduction

In analyzing the determinants of EI in the chemicals manufacturing industry, an understanding of the nature of the Malaysian chemicals industry is vital. For this purpose, a detailed discussion on the development and sub-sectors in the chemicals industry in Malaysia is provided. In a separate section, chemicals industry in the Selangor region is explored and valuable insights are provided from an interview session that was conducted with Invest Selangor Berhad[5].

3.2 Evolution of the Chemical Industry

In the beginning of 1980s, the chemical industry was still at its early stage of development. Due to its sloppy development track record, it required immediate attention from the government to become the leading manufacturing sub-sector in the future. In 1981, the output of chemicals industry accounted for only 0.82% of the national GDP, which was RM 1,232.8 million. In the same year, the sector only employed 18,591 employees, which constituted to 0.3% of total national employment (Malaysia, 1986a). To counter the weaknesses in the chemical industry, it was given extra attention under the First Industrial Master Plan 1986-1995 (IMP1). Under the IMP1 the chemical industry was streamlined into specific sub-sectors in order to design specific action plan to uplift the each sub-sectors.

There were nine main chemical sub-sectors under the purview of IMP1, namely: inorganics, fertilizers, organics, plastics and resins, paints and inks, pharmaceuticals,

[5] Selangor Invest Berhad is a one-stop investment agency that spearheads all investments related matters in Selangor.

pesticides, cosmetics, soap and detergents and miscellaneous chemical products. Among all the sub-sectors, two main sub-sectors were given greater importance, which were the petrochemical product group and fertilizer. Petrochemical product group was seen as potential due to the increasing demand from the plastic processing industry. While fertilizer was seen important as the Malaysian agriculture sector was expected to expand further at that point of time. Furthermore, by looking into the functional properties of the chemical products and the industrial linkages of the chemicals industry, IMP1 classified chemicals and chemical products under the resource based industry cluster.

The success of IMP1 was seen with the implementation of import substitution strategy for petrochemical products. This strategy encouraged the development of large size petrochemicals plants, which manufactured a wide array of basic and intermediate petrochemical derivatives for local and international market. The expansion in the petrochemical sub-sector contributed to a spillover effect on both the forward and backward linked sector of petrochemicals as well. Besides petrochemicals, the oleo-chemical sector was seen to flourish under IMP1. Monitoring the price of palm oil, ensuring sufficient amount of feedstock and allotting PORIM the authority to undertake oleo-chemical R&D activities were several strategies used by the government to develop the oleo-chemical product market (Malaysia, 1987).

With IMP1 ending its tenure, the Second Industrial Master Plan (IMP2) 1996-2005 was introduced. IMP2 was more structured and demanding as compared to IMP1. The strategy under IMP2 was intended to transform the manufacturing sector according to the agenda proposed by the New Development Policy. The IMP2 was designed to fully utilize and invigorate the inherent human and technological capabilities in Malaysian to propel Malaysia into a full-fledged industrial nation by the twentieth century, through resilient industrial linkages and topnotch research and development activities. The highlight of IMP2 was the cluster-based industrial development, which systemically integrated the industries to provide greater access to develop their core competencies. The chemical industry group was placed under the internationally linked cluster and the resource based cluster, which largely covered pharmaceuticals, petrochemical products and food products derived from oleo-chemicals. In tandem line with IMP2, strategic alliance was promoted between petrochemical industries and MNCs to effectively secure foreign technologies under the Seventh Malaysia Plan (7MP). Meanwhile, these alliances were strengthened and new avenues for collaborations were encouraged under the Eight Malaysia Plan (8MP). Among all the regions in Malaysia, Selangor was labeled as the top region for chemical industry cluster based upon the regional distribution index (see Figure 3.1). The industry cluster approach for firms in Klang Valley was extremely successful due to salient business infrastructure, investment opportunities and liberal trade policies (Ariff, 2008).

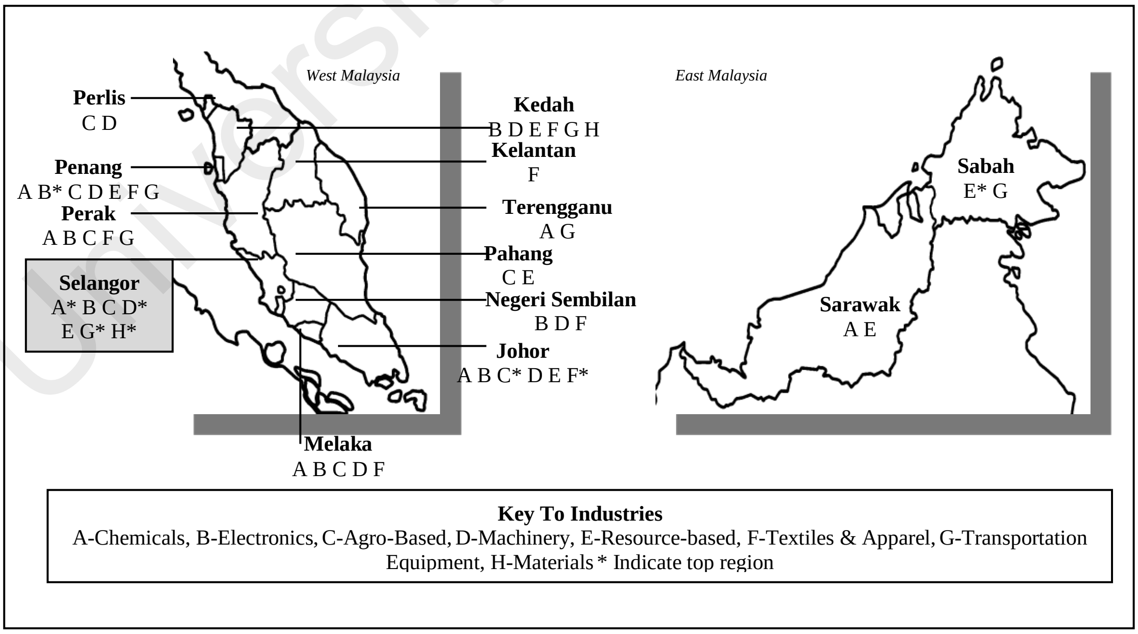

Figure 3.1 : Regional Distribution of Industries
Source: Adapted from Malaysia (1996)

IMP2 escalated the development in the chemical industry. Petrochemical firms were relocated to new designated petrochemical zones that were equipped with better infrastructure to promote greater collaborations. These collaborations promoted new petrochemical products such as vinyl chloride monomer (VCM), synthetic rubber, acetic acid and others. Moreover, the strategic positioning of these firms strengthened the linkages between firms that produced upstream petrochemical products with other sub-chemical related manufacturing firms such as plastic, textile and others. On the other hand, oleo-chemical firms increased their product range by moving from basic ole-chemical production to higher end derivatives (Malaysia, 2006). Lastly, during the 10 years of the IMP2 period, the export of chemicals and chemical products increased from 3.8% to 6.4% (see Table 3.1).

Table 3.1 : Chemical and chemical product export 1996-2005

Industry	1996		2000		2005	
	RM (Million)	Share (%)	RM (Million)	Share (%)	RM (Million)	Share (%)
Total Manufactured Export	154,664.7	100	309,427.4	100	413,132.7	100
Chemical and Chemical Product Export	5,829.1	3.8	12,918.6	4.2	26,301.3	6.4

Source: Adopted from Malaysia (2006)

The third installment of the Industrial Master Plan (IMP3) 2006-2020 was structured to increase the international competitiveness of Malaysian products. Several agendas under the IMP3 to diversify the manufacturing sector and to produce high-end consumer products were intensifying technological innovation, upgrading the human resource skills and expanding firms' competitive capabilities. For the chemical sector specifically, IMP3 aimed to invigorate the sectors inter and intra linkages to heighten the value chain for both petrochemicals and ole-chemicals. As a result, with reference to the manufacturing industry linkages matrix in Figure 3.2, chemicals and chemical products manufacturing holds strong forward and backward linkages. The strong backward linkages of chemicals and chemical product manufacturing sub-sector are with the petroleum and palm oil industry, which provides a huge amount of feedstock and intermediate input to the sub-sector. The petroleum and palm oil industry is the main reason for the existence of chemicals and chemical manufacturing sub-sector. On the other hand, electronics and electrical, automotive, construction, food processing and pharmaceuticals are among the many sub-sectors that chemicals and chemical product manufacturing sub-sector built its forward linkages.

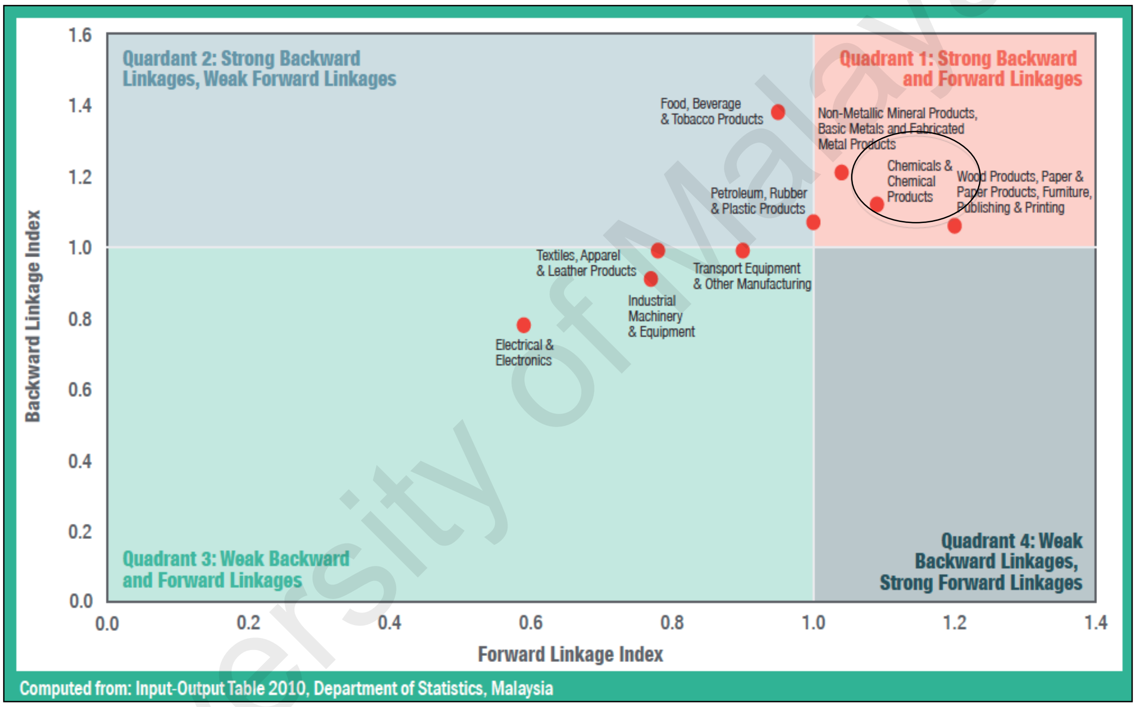

Figure 3.2 : Manufacturing Industries Linkages Matrix, 2010
Source: Adopted from MPC (2015)

In 2009, palm oil and basic ole-chemical accounted for 3.3% of GDP. By looking into the increasing potential of the oleo-chemical industry, under the Tenth Malaysia Plan (10MP), the government vigorously promoted Malaysia as an investment hub for oleo-chemical based products. The investment in palm oil based products was encouraged through various initiatives such as tax waivers, special allowances, R&D assistance and others. Additionally, integrated oleo-chemical zone were developed to increase the production of downstream oleo-chemical derivatives and value added products. For this purpose, the government allocated a grant worth of RM543 million. Interestingly, funds allocated specifically for oleo derivatives and bio-based acquisition were taken up by 83%, while allocation for food and health based products were taken up by 100% (PEMANDU, 2014).

All the three IMP's coupled with the formation of ASEAN Free Trade Area (AFTA), provided the chemical industry with a greater market size vastly benefited the chemicals and chemical products manufacturing sub-sector. Furthermore, the endowment of abundance of natural resources, excellent infrastructure and a never-ending flow of feedstock provided a strong footing for the chemical industry in Malaysia to flourish. From a mediocre industry, it has grown to be one of the most developed chemical industry in the world (MPC, 2015).

3.3 Chemical Manufacturing Industry Sub-Sectors

The chemicals and chemical products manufacturing industry sub-sectors are complex and heterogeneous. The sub-sectors are rigorously interlinked where; product of one sub-sector serves as raw material to other sub-sector or plant. Therefore, the chemicals and chemical products manufacturing industry are its own biggest buyer as well as seller. To determine the specific sub-sector within the industry was not easy. This is because there is no consistency between the ministries (MITI, MIDA, MATRADE, EPU and others) and chemical associations (CICM) in classifying the sub-sectors. To ensure consistency in explaining sub-sectors in the industry and to ease the process of data collection, the sub-sector provided classified by different ministries and chemical associations were calibrated. From the calibration and crosschecking ten sub-sectors were put together. Additionally, for the purpose of this study, the chemicals and chemical products manufacturing industry is simply referred as chemical manufacturing industry. The ten sub-sectors in the chemical manufacturing industry are as following:

1. Petrochemicals
2. Oleo-chemicals
3. Industrial chemicals
4. Plastics in Primary Forms and of Synthetic Rubber
5. Adhesives and sealants
6. Paint and coatings
7. Printing Ink, dye and related products
8. Agriculture Chemicals
9. Industrial gases
10. Soap, detergent and cosmetics

3.3.1 Petrochemical

Petrochemical industry in Malaysia has been successful due to the wide availability of petrochemical feedstock. Malaysia is endowed with crude oil reserves worth of 5.8 billion barrels (world's 24th largest) and natural gas reserves worth of 14.66 billion barrels (world's 15th largest). The daily production of natural gas is 2900 million barrels and the production of crude oil is to 2,350,000 cubic meters. Natural gas is an essential feedstock for the petrochemical industry, which is in the form of ethane, propane, butane, and condenses.

Besides abundance of feedstock, the setup of an excellent infrastructure provides an added advantage. The strategically integrated petrochemical complexes offer unified utilities, extensive transport network and adequate storage services (see Figure 3.3). This strategic integration has contributed to lower capital and operation cost. Over the years, investments in petrochemical industry, which focused on building the feedstock, improving the facilities, vitalizing existing products and expanding the product line has provided Malaysian petrochemical products a greater comparative advantage as compared to their competitors (MITI, 2015).

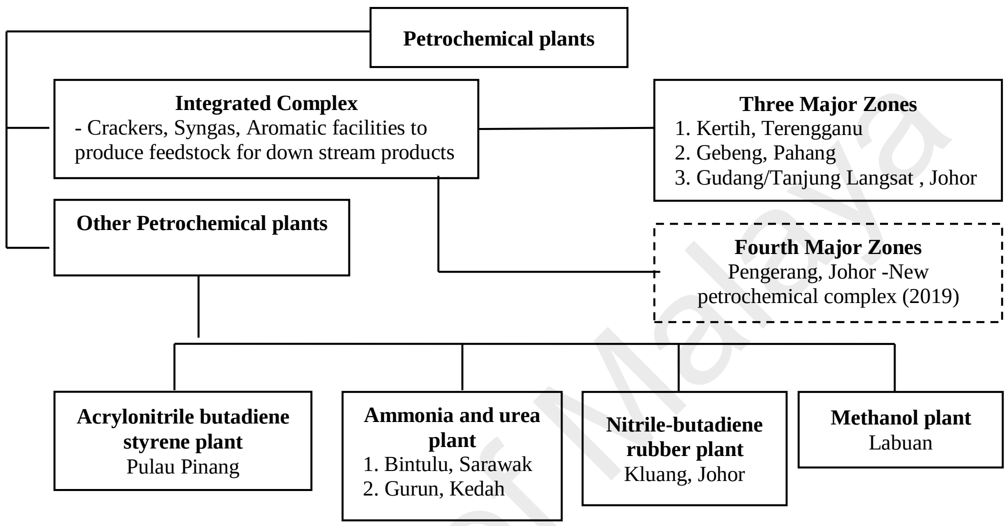

Figure 3.3 : Major Petrochemical Plants in Malaysia
Source: Adapted from MIDA (2014c)

Petrochemicals include primary and intermediate petrochemicals (see Table 3.2). Primary petrochemicals are first order derivatives of hydrocarbon sources and intermediate petrochemicals are second order derivatives, which are produced by further chemical processing. Petrochemicals are used by many other industries such as plastic, paint, coatings and other industrial chemicals. Table 3.2 also provides a detailed summary of the higher-end petrochemical derivatives produced by main petrochemicals plants in Malaysia. Among the major petrochemical manufacturers in Malaysia are PETRONAS, Dairen, BASF, Kaneka, Eastman Chemicals, Honam and Idemitsu.

Table 3.2 : Petrochemicals

Major Hydrocarbon	Direct Feedstock	Methane, Benzene, Toluene, Xylenes
	Steam Crackers	Ethane, Propane, Butanes, Naphtha, Gas
Primary Petrochemicals	Olefins	Ethylene, Propylene, Butylene
	Aromatics	Benzene, Toulene, Mixed Xylenes
	Gas	Methane
Petrochemical Derivatives	Petrochemical Plant Kertih	Paraxylene, Ammonia, Acetic Acid, Polyethylene, Ethanolamines, Ethoxylates, Glycols Ether, Butanol, Butyl Acetate, Ethylene Oxide, Ethylene Glycol, Low Density Polyethylene
Petrochemical Derivatives	Petrochemical Plant Gebeng	Paraxylene, Ammonia, Acrylic Acid and Esters, Butyl Acetate, Acetic Acid, Ethylene Oxide, Butanol, Gamma-butyrolactone, Polyethylene, Syngas, Ethanolamines, Butanediol, Polyster, Copolymers, Ethylene Glycol, Ethoxylates, Glycols Ether, MTBE, Purified Terephtalic Acid (PTA), Polypropylene, Propylene, Butyl, Acrylate, Polyacetals, Dispersion Polyvinyl Chloride, Tetrahydrofurane, Oxo-alcohols, Polybutylene Terephthalate (PBT), Methyl Methacrylates Copolymers, Low Density Polyethylene, Phthalic Anhydride and Palsticizers
	Petrochemical Plant P.Gudang-T.Langsat	Ethylene, Propylene, BTX, Polyethylene, Polypropylene, High Impact Polystyrene, Ethylbenzene, Styrene Monomer, Expandable Polystyrene, Ethylene Vinyl Acetate
	Petrochemical Plant Bintulu	Ammonia, Urea, LNG, Synthetic Gas Oil, Synthetic Kerosene, Synthetic Naphtha, Synthetic Solvents, Synthetic Detergent Feedstock, Synthetic Paraffin Wax/ Waxy/ Raffinate

Source: Adapted from MIDA (2014c)

3.3.2 Oleo-Chemicals

Malaysia is the second largest palm oil producer after Indonesia and delivers approximately 20% of fatty acids and 12% of fatty alcohols globally. The abundance feedstock for oleo-chemicals (palm oil and palm kernel) and increasing global demand for bio-based consumer products especially soap, detergent, pharmaceuticals and personal care has given a huge boost to the ole-chemical industry in Malaysia. Moreover, increasing environmental awareness has encouraged the industries to substitute petrochemical based polymers to bio-based polymers, especially in the plastic and fabric industry (MATRADE, 2014). There are three main forms of oleo-chemicals, namely: basic oleo, oleo derivatives and specialty oleo (see Figure 3.4). Currently, oleo-chemical firms in Malaysia are focusing on the production of basic oleo-chemicals, which is less profitable as compared to oleo derivatives and specialty oleo. Looking into these shortcomings, the government with the assistance of the Malaysian Investment Development Authority is encouraging greater interments into higher-level oleo-chemicals. Major oleo-chemical producers are IOI Group, Emery Oleochemicals and KLK Oleo.

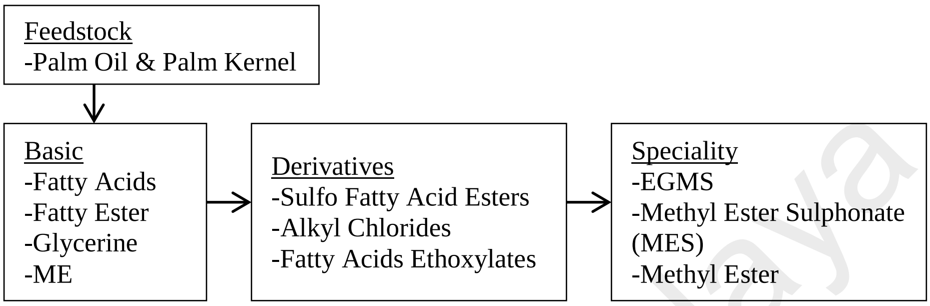

Figure 3.4 : Oleo-chemicals

3.3.3 Industrial Chemicals

Industrial chemicals are largely in the form of basic organic and inorganic chemicals, which serves as an intermediate input to produce major consumer products. Basic industrial chemicals are supplied to sectors mainly within the chemical industry such as agriculture and personal care. However, there are also various other industries besides the chemicals industry that depends on basic chemical such as electronics, construction, automotive, steel and others. Industrial chemicals are grouped into organic and inorganic category based on their chemical compound (see Figure 3.5). Industrial chemicals are important source of resources in the production of synthetic rubber, cosmetics, soap, detergents, fertilizers, paints and many others. Among the leading firms that produce industrial chemicals are BASF PETRONAS Chemicals, CCM Chemicals, Dow Chemical DuPont, Fatty, NSL Chemicals and RP Chemicals.

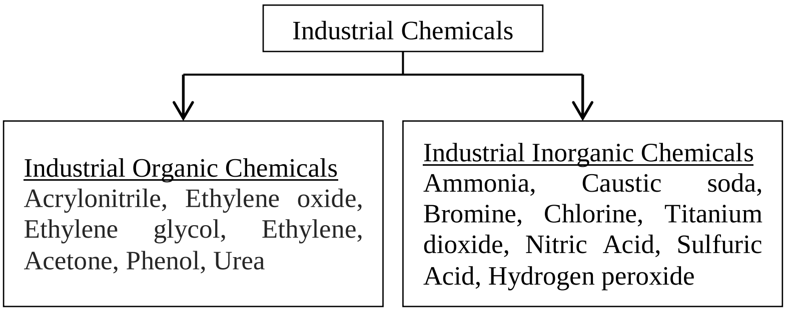

Figure 3.5 : Industrial chemicals

3.3.4 Plastics in Primary Forms and of Synthetic Rubber

The exuberant Malaysian petrochemicals industry is also credited for developing indigenous downstream plastic industry. This is made possible due to the solid provision of feedstock for the plastic processing. The industry is presently dominated by more than 1,450 firms and is a net exporter of plastic products. However, in this sub-category of chemical products, the focus is only on plastics in primary forms and of synthetic rubber. Plastics are the primary form that refers to the physical form of the plastic, which can be in the form of liquids, pastes, solutions and others and different shapes such as blocks, lumps, powder, flakes and others. Plastics of synthetic rubber on the other hand, refer to man-made polymer, which are synthesized from petroleum by-products (MIDA, 2014b).

Major products under this sub-sector are Polyethylene (PE), Polyvinyl Chloride (PVC), Polyethylene Terephthalate (PET), Polypropylene (PP), Polystyrene (PS), Acrylonitrile-butadiene-styrene (ABS) and Nylon. PETRONAS and their allies' in the petrochemical sub-sector largely produce plastics in primary forms. Several other big players who manufacture plastics in primary forms and synthetic rubber are Nylex, BASF, Revertex, Kaneka, EP Polymers and Torray.

3.3.5 Adhesives and Sealants

Adhesives and sealants are two products that are manufactured using major similar chemicals compounds, however, both of them serve different purpose. Adhesives are used to create bond between two surfaces. Meanwhile, sealant is used to close penetrable barriers so that it becomes airtight or watertight. Many prime industries such as automotive, construction, woodworking, labeling transportation, footwear, packaging and others demand adhesives and sealants. The major players for adhesives and sealant manufacturing are Eastman Chemical and Cosmo Scientex.

3.3.6 Paint and Coatings

Their primary motive of paint and coatings is to provide a protective shield to surfaces. There are extra credit given to both the products that differentiates them, where coating is credited for giving additional attention on the protective properties, and paint is credited for giving color and a decorative feature to the surfaces. This sub-sector also takes into account other paint related products such as enamels, lacquers, varnishes, undercoats, primers, sealers, fillers and others.

This subs-sector plays an important role, as there is a huge backward integration with other chemical raw materials within the chemical industry such as oils, resins, solvents, pigments, driers and others, thus encouraging the manufacturing of other chemical products. Paint and related products are widely used by construction, automobile and specialized manufacturing industries. Main players for the paint and coating manufacturing are Jotun, Akzo Nobel, Nippon Pigment, PPG Coatings and Kansai Coatings.

3.3.7 Printing Ink, Dye and Related Products

This sub-sector specifically looks into printing ink for example tonner and dye used for fabrics and decorative purposes. Additionally, this sub-sector also includes coloring products used in food manufacturing. Among the main manufactures of printing ink and dyes are DIC and Jadi Imaging Tecnologies.

3.3.8 Agriculture Chemicals

Agriculture chemicals consist of a wide range of pesticides and fertilizers. Leading firms under this category are BASF, CCM Fertilizer, PETRONAS Chemicals Fertilizer Kedah, AGRI-Sabah Fertilizer, TMKAY Fertilizers, Union Harvest and other.

3.3.9 Industrial Gases

The major industrial gases manufactured and widely used by a wide spectrum of industries are oxygen, carbon dioxide, nitrogen, hydrogen and acetylene. Liquefied gases such as LPG that are sold to commercial users are also included in this sub-category. Prime manufacturers of industrial gages are PETRONAS, Shell and Linde.

3.3.10 Soap, Detergent and Cosmetics

Specific products that belong soap, detergent and cosmetics group are listed in Table 3.3. Kao Soap, Colgate-Palmolive and United detergent industries are among the major manufacturers of these products.

Table 3.3 : Soap, detergent and cosmetics

Soap	• Toilet soap, laundry soap, medicated, industrial and other soaps
Detergent	• Powder detergents, detergent bars, dishwashing liquids, fabric softeners and scouring powders
Cosmetics, perfumes and toilet preparations	• Beauty creams, skin care products, lipstick and manicure preparations • Talcum powder and face powder • Perfumes including deodorants and colognes • Hair care products such as shampoos, hair cream/lotions and hair dyes • Dental care products such as toothpaste and mouthwash

Source: Authors own compilation from various sources

3.4 National Chemicals Industry Performance

3.4.1 Total Capital Investment

Chemical manufacturing industry was recognized as an important National Key Economic Area (NKEA) and the largest investment-generating sector under the Economic Transformation Plan (ETP) that was launched in 2010. This NKEA paid greater attention to the petrochemical and oleo-chemicals sub-sector. Malaysia continued to attract investment in the chemicals manufacturing industry through various initiatives conducted by the Malaysian Investment Development Authority. Among the prime government strategies under IMP3 is to increase domestic investment for the chemicals industry. From 2008 to 2014, the total capital investment for the chemical manufacturing industry is 41797.9 million (see Table 3.4). The investment in the chemical manufacturing industry is among the top three highest investment-generating industries. Meanwhile, total capital investment in the petroleum products, which is the fourth highest investment grouser from the list of 15 industries, includes investment in the petrochemicals.

From the total capital investment for the duration of 2008-2014, foreign capital investment for all the industries is RM 222.5 billion. The share of foreign capital investment for the chemical manufacturing industry from the total foreign capital investment is 13.6% (see Figure 3.6). This industry has the third largest share of foreign capital investment after electronics & electrical products and basic metal products industry. On the other hand, for total domestic capital investment of RM141.3 billion, the share total capital domestic investment of the chemical manufacturing industry is 8.1%. It is among the main five domestic capital investment contributors.

Table 3.4 : Approved manufacturing projects by industry, aggregate 2008-2014

Industry	Total Capital Investment (RM Million)			Number of Projects
	Foreign	Domestic	TOTAL	
Electronics & Electrical Products	74024.2	6798.3	80822.5	828
Basic Metal Products	42393.7	20433.5	62827.2	274
Chemical & Chemical Products	30348.4	11449.5	41797.9	529
Petroleum Products (Inc. Petrochemicals)	13111.7	27441.1	40552.8	91
Transport Equipment	9157.7	24724.4	33882.1	541
Food Manufacturing	10751.4	10736.3	21487.7	500
Non-Metallic Mineral Products	12487.8	7323.8	19811.6	194
Others	6981.8	5698.4	12680.2	586
Machinery & Equipment	5594.5	5866.8	11461.3	626
Fabricated Metal Products	5869.7	5377.9	11247.6	575
Rubber Products	3008.9	6256.0	9264.9	171
Plastic Products	2534.7	3031.1	5565.8	381
Paper, Printing & Publishing	2406.3	2185.2	4591.5	159
Textiles & Textile Products	2861.1	1266.4	4127.5	126
Wood & Wood Products	965.1	2679.5	3644.6	262
TOTAL	222497	141268	363765	5843

Source: Compiled and computed from MIDA (2008, 2009, 2010, 2011, 2012, 2013, 2014a)

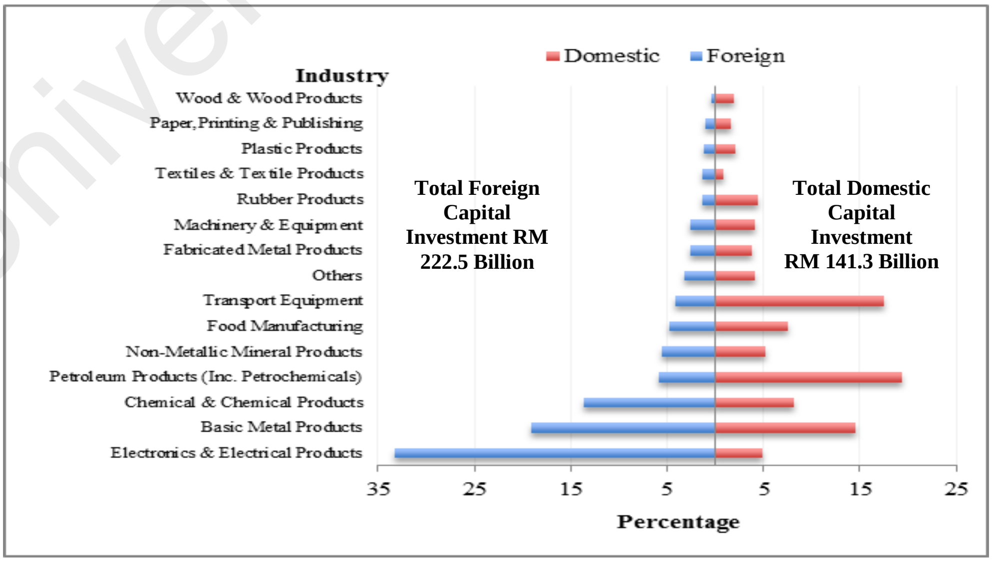

Figure 3.6 : Share of foreign & domestic capital investment in approved manufacturing projects by industry from 2008-2014

Source: Compiled and computed from MIDA (2008, 2009, 2010, 2011, 2012, 2013, 2014a)

Besides the chemical manufacturing industry, the petroleum products industry, which also takes into account petrochemical products, has a substantial share of foreign (5.9%) and domestic (19.4) capital investment. The domestic capital investment for the petroleum products and petrochemicals is the highest among all the industries. This investment would have positive impact on the chemical manufacturing industry, as petrochemicals are a major source of input for the industry. Additionally, with the completion of ambitious petrochemical projects such as PETRONAS Refinery and Petrochemicals Integrated Development (RAPID) projects (Johor) and PETRONAS Chemicals Group's Sabah Ammonia Urea (SAMURA) projects (Sabah), which involves an investment of approximately RM 64.5 billion, the performance of the chemical industry is expected to escalate faster (PEMANDU, 2013).

The state distribution of the total capital investment for the chemicals manufacturing industry specifically could not be determined due to the limited availability of the data. However, the distribution of the total capital investment for all the industries according to the states provides a little indication where majority of the chemicals manufacturing industry capital investment is allocated. Five main states that received the largest share of the total capital investment from year 2008 to 2014 (see Figure 3.7), worth 363.8 billion are Johor (19.5%), Selangor (18.3%), Sarawak (16.1%), Pulau Pinang (13.3%) and Kedah (5.7%). In terms of number of manufacturing projects, the state of Selangor (1876 projects), Johor (1243) and Pulau Pinang (895) are on the top the list. Therefore, from this information it could be inferred that large share of chemicals industry capital investment went to the state of Selangor, Johor, Sarawak and Pulau Pinang respectively.

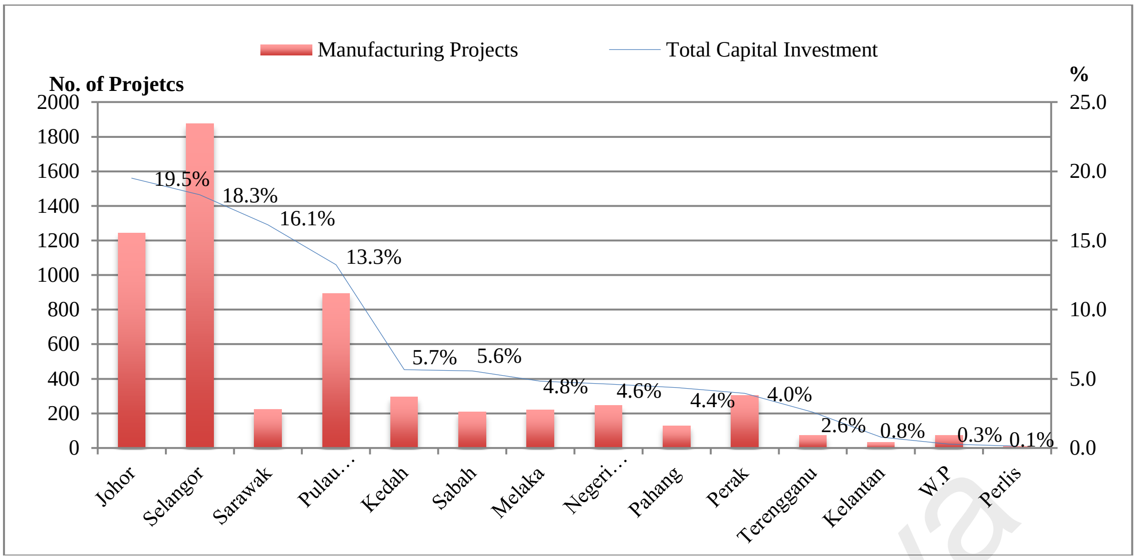

Figure 3.7 : Share of total capital investment in approved manufacturing projects and number of manufacturing projects approved by state from 2008-2014
Source: Compiled and computed from MIDA (2008, 2009, 2010, 2011, 2012, 2013, 2014a)

3.4.2 Export Performance

Chemical manufacturing sector is the second largest contributor to Malaysia's total exports of manufacturing goods after the electronics and electrical products. The sub-sector is also classified under the export-oriented sub-sector. Chemical manufacturing export accounted for 8.7% of the total manufactured export in 2013 (see Table 3.5). While for 2014, the provisional figures indicated that the export share was maintained at a similar percentage.

In comparison to the chemicals and chemical products, the electrical and electronics products recorded higher exports, but the prior has a better export growth performance. With reference to Table 3.5, from 2010 to 2014, export growth for the chemicals and chemical products had frequently superseded the electrical and electronics products. Furthermore, from 2009 to 2014, the average export growth for the chemicals and chemical products was 7.5% higher compared to the electrical and electronics products (see Figure 3.8). However, for the chemicals and chemical products, the average import growth is higher as compared to the export growth by 1.3%.

Table 3.5 : Malaysian chemicals and chemical products and electrical and electronics products export and growth

Product	Export (RM Billion)					
	2009	2010	2011	2012	2013	2014P
Total Manufactured good	412.97	461.05	471.01	470.25	548.10	587.30
E&E Products	230.08	249.91	237.26	231.16	237.00	256.20
C&C Products	32.90	40.70	47.18	46.30	47.50	51.50
	Import (RM Billion)					
Total Manufactured good	358.95	430.28	447.12	461.98	559.80	589.70
E&E Products	159.77	189.40	178.15	174.73	179.60	190.80
C&C Products	36.94	45.10	51.14	52.05	55.90	62.10
	Growth (%)					
E&E Products	Export	8.6	-5.1	-2.6	2.5	8.1
	Import	18.5	-5.9	-1.9	2.8	6.2
C&C Products	Export	23.7	15.9	-1.8	2.5	8.4
	Import	22.1	13.4	1.8	7.4	11.1

Note: E&E=Electrical and Electronics, C&C=Chemicals and Chemical, P=provisional data
Source: Compiled and computed from MITI (2010, 2011, 2012, 2013, 2014)

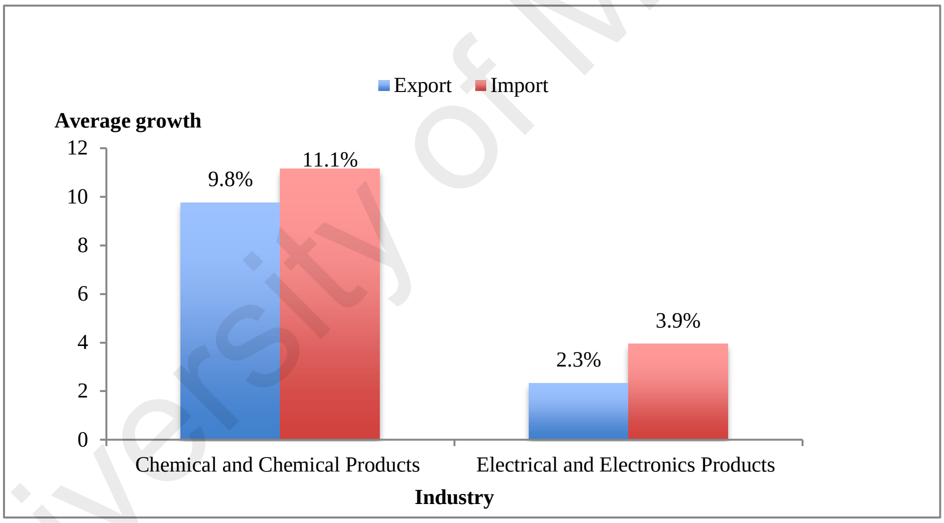

Figure 3.8 : Export and import annual average growth for chemicals & chemical products and electrical and electronics products (2009-2014)
Source: Compiled and computed from MITI (2010, 2011, 2012, 2013, 2014)

From the total exports of chemical manufacturing industry, the petrochemicals and oleo-chemicals sub-sector contributes to the largest share of export. In 2014 and 2013, the share of petrochemicals was more than 40% (see Table 3.6). The major petrochemicals that were exported are polymers of ethylene in other forms; methanol and saturated polyesters in primary forms (see Figure 3.9).

Table 3.6 : Export of petrochemicals and ole-chemicals (2013-2014)

Description	2013		2014		Change (Value)	Change %
	RM Mil	Share %	RM Mil	Share %		
Total exports of chemicals	47470.10	100	51509.20	100	4039.10	8.5
Petrochemicals	20939.80	44.1	22456.90	43.6	1517.10	7.2
Oleo-chemicals	9297.70	19.6	11286.70	21.90	13447.40	21.40

Source: Adopted from MATRADE (2014)

In similar years, the share of ole-chemicals exports was around 20%, which included major ole-chemicals such as industry fatty alcohols, palm fatty acids distillates, stearic acid, soap noodles and acetic acid. Furthermore, the exports of all major petrochemicals and ole-chemicals increased from 2013 to 2014 (see Figure 3.9). The main demand for petrochemicals is from China, India and Indonesia. While the major demand for oleo-chemicals is from China, United States of America, India, Netherland and Singapore. For the chemicals and chemical product export as a whole, the main export market is China, Singapore, Indonesia, Thailand and India. The primary import market is China, Singapore, United States of America, Japan and Indonesia.

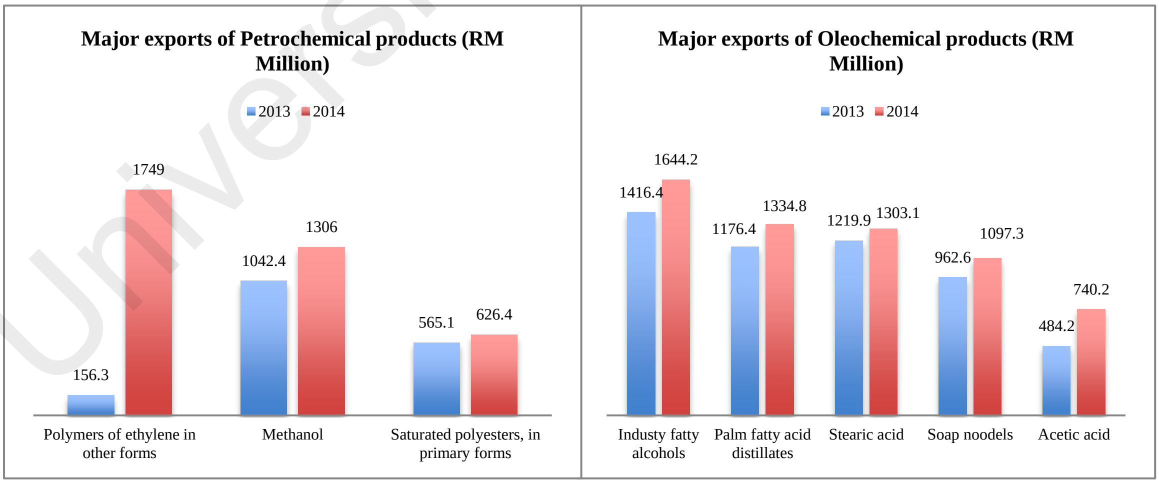

Figure 3.9 : Major exports of petrochemicals and oleo-chemicals (2013-2014)
Source: Adopted from MATRADE (2014)

3.4.3 Gross Output, Value Added, Employment and Income

In the Malaysian economy, the manufacturing sector remains the second largest sector, with a total GDP contribution of RM 205 billion in 2014. The sector recorded a GDP growth of 6.2% in 2014 as compared to 3.5% in 2013. Among the manufacturing sub-sectors, chemicals and chemical products were the third largest contributor to an added value of 10.9%, headed by the electronics & electrical and refined petroleum products with a contribution of 25.7% and 12.7% respectively (see Figure 3.10).

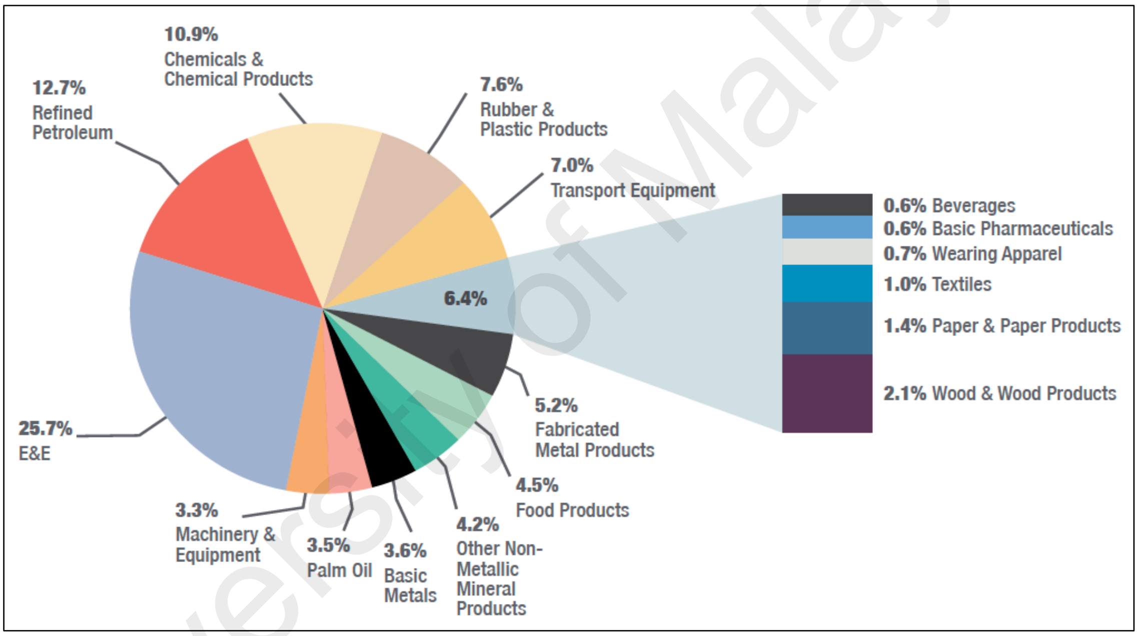

Figure 3.10 : Added value contribution of selected manufacturing sub-sectors, 2014
Source: Adopted from MPC (2015)

On the employment frontier, in 2014, the total manufacturing employment was 2.3 million, which accounted for 16.5% of the total Malaysian workforce. The employment in the chemicals and chemical products sub-sector was 4.2% of the total employment in the manufacturing sector (see figure 3.11). Even though the sub-sector has a small share of employment, but it is among the highest paid sub-sectors. Figure 3.12 provides a snapshot of the relationship between the share of high-skilled jobs and average wage across industries in Malaysia. By looking carefully at the manufacturing cluster, the top three manufacturing related industries that require high skilled workers are refined petroleum industry, machinery industry and chemical related manufacturing. Among them, the chemical related manufacturing industry is ranked as the second highest paid industry. Furthermore, by looking at the size of the bubble, among the top three manufacturing industries, the chemical related manufacturing industry employed the highest number of workers.

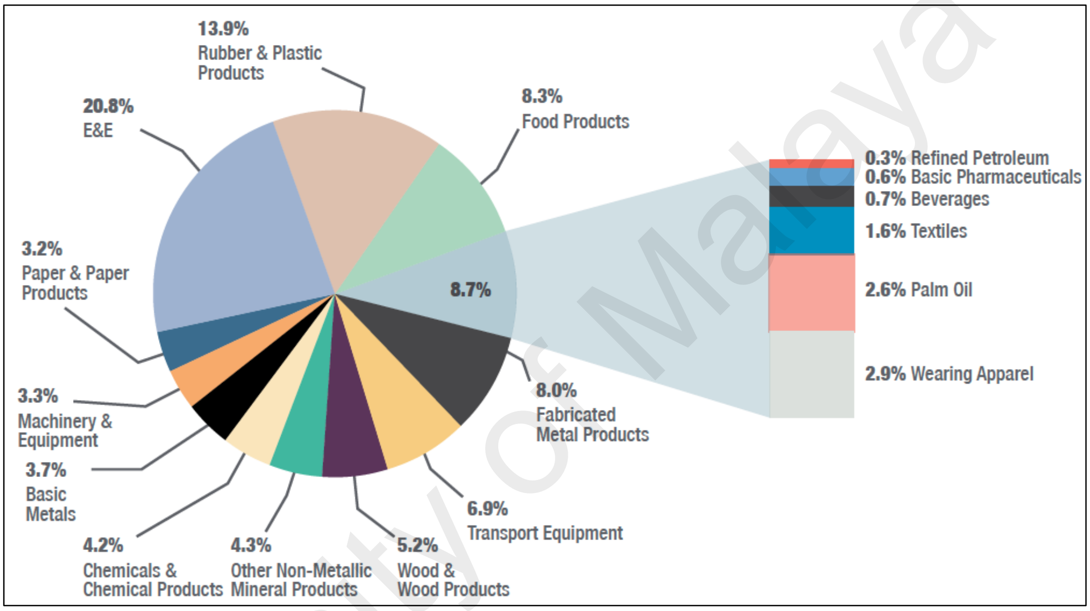

Figure 3.11 : Employment distribution among selected manufacturing sub-sectors, 2014
Source: Adopted from MPC (2015)

The strong backward and forward linkages of the chemicals and chemical products industry have encouraged high-skilled and high paying jobs in the industry. Based on MPC (2015), an employee in the manufacturing sector receive an average of RM 2,796 per month, followed by the chemical and chemical product sub-sector at RM 3,857 per month. An employee in the refined petroleum sub-sector receive an average of RM 8,679 per month. The report further emphasized that the wage range strongly correspondence with productivity level of these sub-sectors. Moreover, this sub-sector is vigorously involved in R&D activities, which often results in new products and production technology, thus contributing to higher wage demand. Employment in the chemicals and chemicals products sub-sector is centered on highly skilled workforce comprising of technical professionals, such as scientist, engineers and specialized technicians.

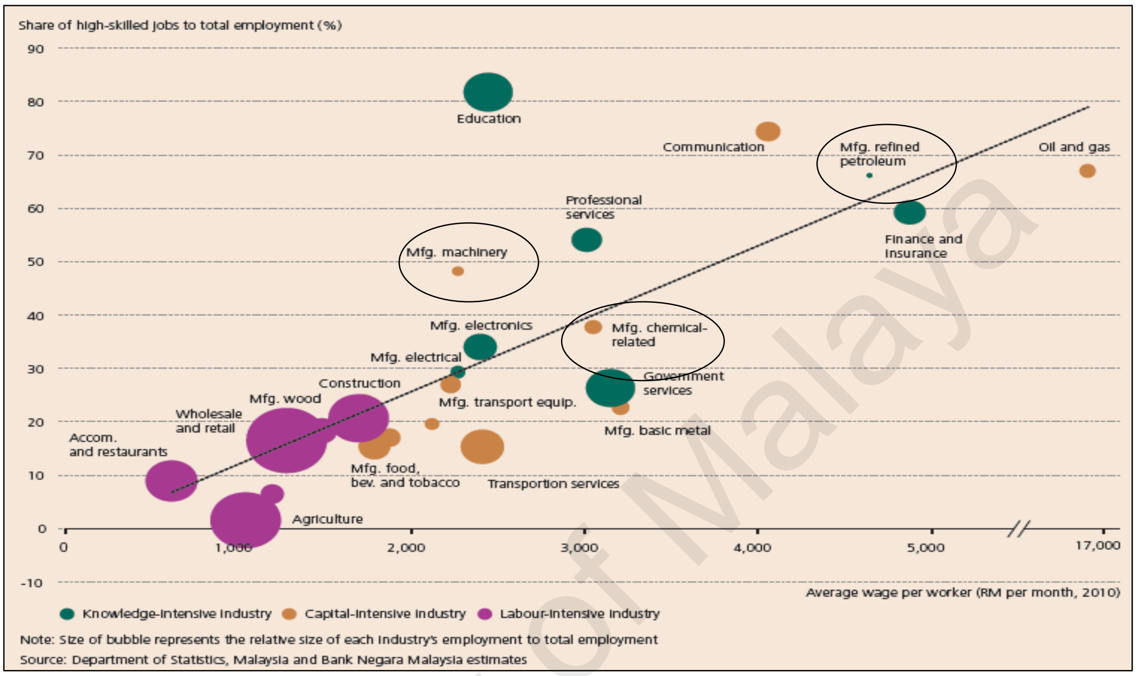

Figure 3.12 : Positive relationship between share of high-skilled jobs and average wage per worker
Source: Adopted from BNM (2015)

3.5 Chemical Manufacturing Industry in Selangor

3.5.1 Investment in the Chemical Manufacturing Industry

The state of Selangor is the top investment destination in Malaysia primarily due to its strategic location, which is within the central area of the Klang Valley region. This strategic positioning provides industries a favorable access to every region and industrial areas/parks in Malaysia. Additionally, with reference to Figure 3.13, there are several other key benefits that Selangor has to offer such as excellent infrastructure and connectivity, access to wide supply of industrial property, large pool of skilled workforce, established data centers and technology parks. Furthermore, to ease the process of investment in Selangor, a premier investment agency known as Invest Selangor Berhad (ISB) was established. The purpose of this agency is to assists potential and existing investor, by providing firsthand information and advisory services to conduct businesses in Selangor.

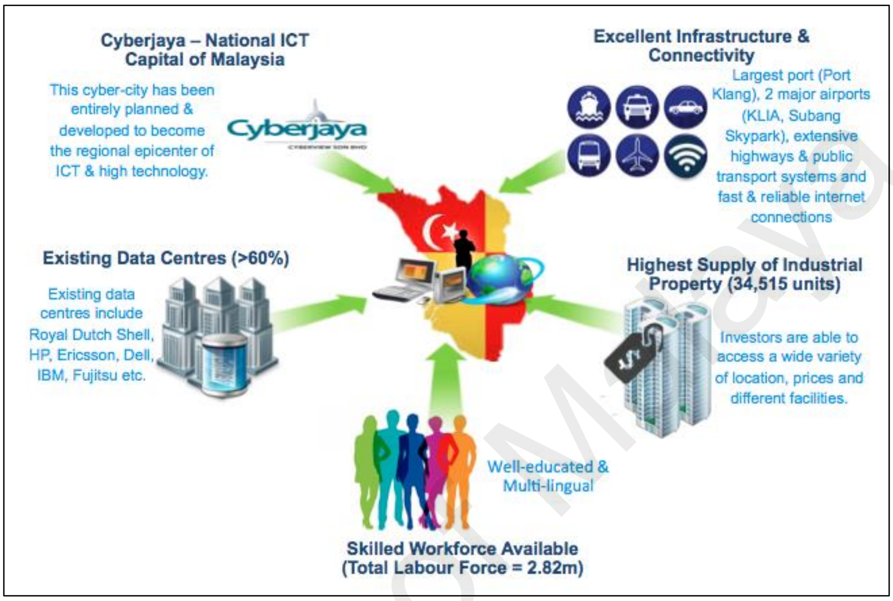

Figure 3.13 : Key benefits to invest in Selangor
Source: Adopted from ISB (2013)

In 2015, the total capital investment in the chemical manufacturing industry for the Selangor region was RM 652.8 million (see Figure 3.14). This sub-sector is among the top ten total capital investment-grossing sub-sectors in Selangor. Malaysia is the next destination for investment in chemicals in ASEAN after Europe and The United States due to its strong distribution network and continuous development in the sub-sector. Understanding the future potential of the chemicals sector, the ISB is in the stage of completing the Selangor Industrial Master Plan (SIMP). The SIMP is expected to provide more comprehensive plan for the chemical industry. Under the SIMP, special attention is given to specialty chemicals, as other industries are also dependent. Additionally, based on the global demand, there is a vast scope for specialty chemicals industry to expand in the future (S. Schneider, personal communication, October 8, 2015)[6]

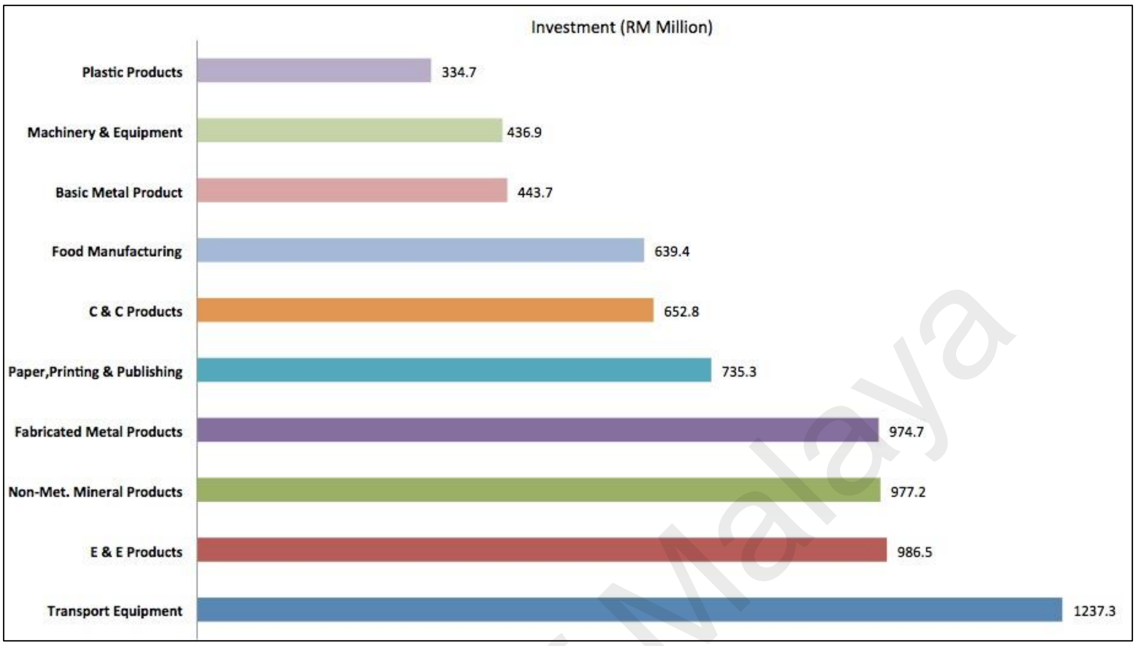

Figure 3.14 : Top 10 Approved Investments in Manufacturing Projects by Industry, Selangor, 2015
Note: C&C=Chemical and chemical, E&E=Electrical and electronics
Source: Adopted from ISB (2015)

3.5.2 Landscape of Chemical Manufacturing Firms

Chemicals and chemical products manufacturing firms are widely located across Malaysia. Figure 3.15 presents the state distribution of chemical firms according to their share of sales revenue. From the total sales revenue of RM58420 billion, Selangor has the largest share at 35.8%, followed by Johor and Pulau Pinang with a share of 13.1% and 12.5% respectively. In comparison between the aforementioned three states, there is a huge difference between the percentages of sales revenue held by Selangor as compared to the other two states. Besides, the abovementioned states, other states/federal territories have relatively much smaller shares. Therefore, based on the

[6]To obtain better insights of the chemical manufacturing industry in Selangor an interview was conducted with Sven Schneider, the Head of Corporate Communication and Strategic Planning Division from Invest Selangor Berhad (ISB). The interview was conducted on the 8 October 2015 at 10.30am in ISB Shah Alam, Selangor.

share of total sales revenue, Selangor is the largest chemical manufacturing state in Malaysia.

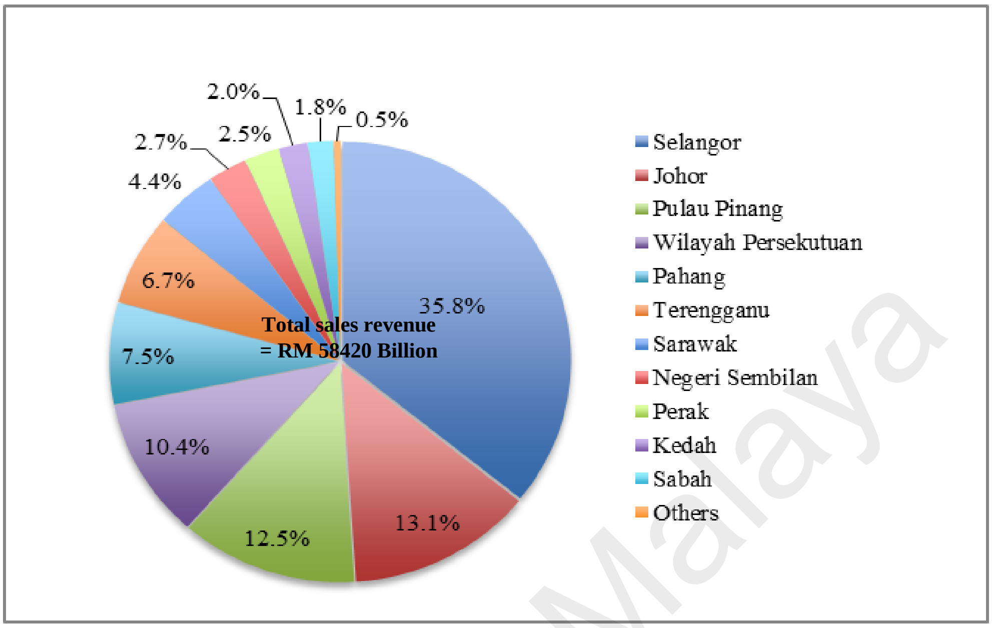

Figure 3.15 : Distribution of chemical and chemical product manufacturing firms according to state based on their total sales revenue
Note: The statistics are based on author's own computation. Sales revenue figure were obtained from the Companies Commission of Malaysia in 2014. Total number of chemicals and chemical products manufacturing firms = 573. Others include federal territory of Labuan, Perlis, Kelantan and Melaka.
Source: Authors own computation using data obtained from Companies Commission of Malaysia

To further understand the distribution of chemical manufacturing firms within the chemicals industry, firms in each states/territories were divided according to the 10 chemicals industry sub-sectors (see Figure 3.16). Based of the figures, majority of the specialty chemicals manufacturing firms are located in Selangor. The firms are from the industrial gases (42.6%), industrial chemicals (33.3%) adhesives & sealants (65.0%), and paint & coatings (57.1%). For firms that derive their chemical products from upstream petroleum processing like petrochemicals (26.9%) and plastic in primary form (36.4%), are also mainly located in Selangor. However, for petrochemicals, other states like Pahang, Terengganu, Johor and Pulau Pinang must also be taken into consideration. Even though these states have smaller percentage of firms manufacturing petrochemicals in comparison to Selangor, they are large in terms of size. Moreover, these firms support the downstream petrochemical manufacturing in Selangor. Next, firms under the following sub-sectors: agriculture chemicals (42.7%), soap, detergent & cosmetics (47.8%) and printing ink & dye (72.5%) are also largely located in Selangor. Lastly, for the ole-chemicals sub-sector, the firms are primarily located in Johor (39.1%) followed by Selangor (30.4%).

Both downstream petrochemical and oleo-chemicals activities are largely located in Selangor. Downstream activities are often capital intensive and more lucrative compared to the upstream segment. The downstream petrochemicals and oleo-chemicals are an important source of input for specialty chemicals manufacturing and for other industries, which are located in Selangor. This may be the reason for the Selangor state government and ISB to pay great attention to the specialty chemicals product manufacturing.

Since 2013, the Selangor state government has focused on the high technology industry, which produces products of high value and creates opportunities for high paying jobs. Specialty chemicals industry is among them. In the future, the ISB plans accumulate the specialty chemicals firms, palm oil board, university research and R&D centers together under their purview. As for now, it is still unclear on the driving force of the chemicals industry agenda. Furthermore, due to strong backward and forward linkages in the chemicals industry, it is extremely difficult to identify the key force behind the industry. Therefore, the ISB plans to take charge of it (S. Schneider, personal communication, October 8, 2015)

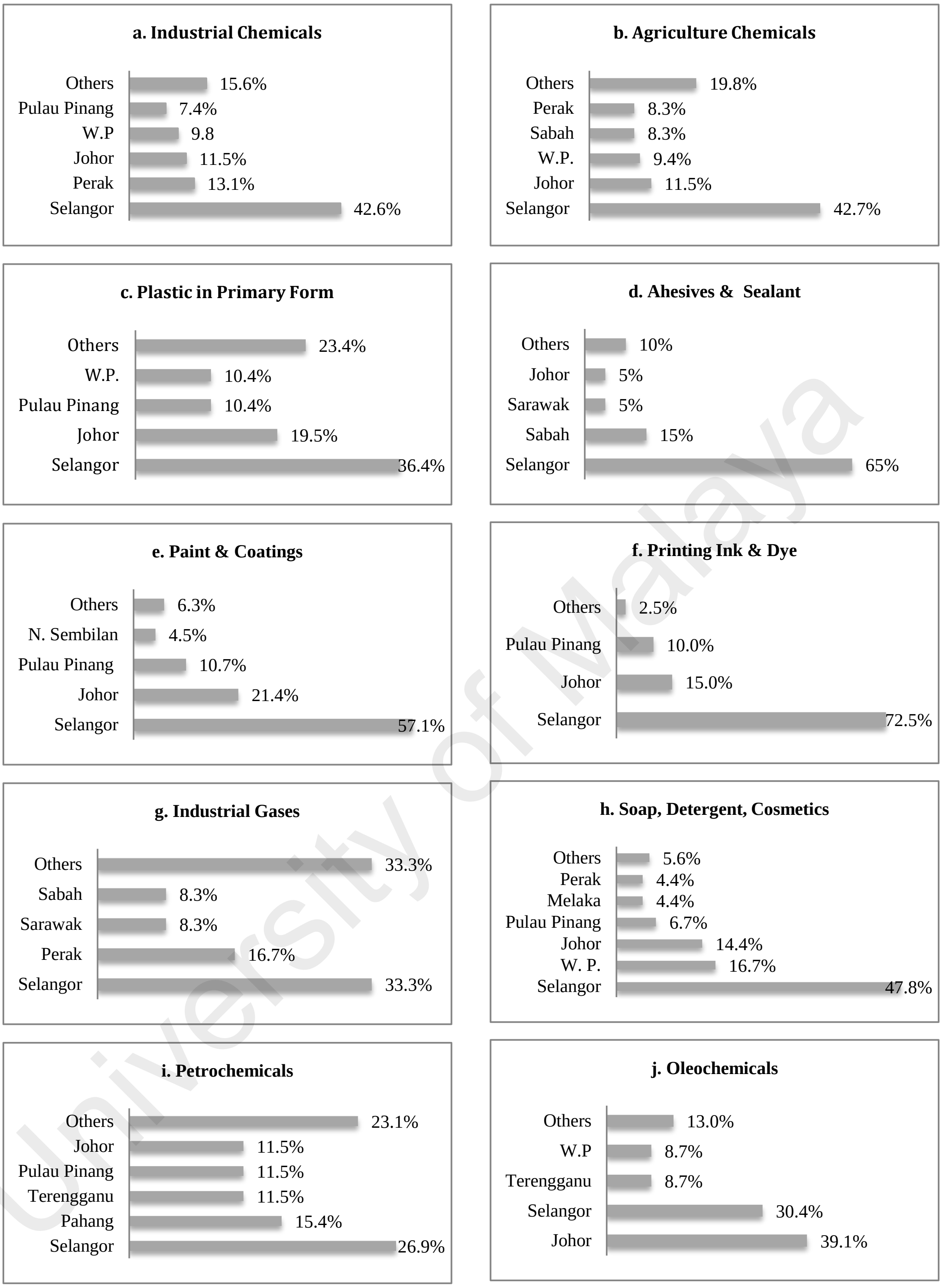

Figure 3.16 : Regional distribution of chemicals and chemical product manufacturing firms based on sub-sectors

Note: The figures are based on author's own computation. List of chemicals manufacturing firms were obtained from the Companies Commission of Malaysia (SSM). Total number of chemicals and chemical manufacturing firms = 573. The nature of business information provided for each firms was used to regenerate these statistics. If the nature of business falls into any of the 10 chemical sub-sectors, a score of 1 was given to the respective sub-sector. A company may fall into more than one sub-sector. Lastly, for every state the total score for each sub-sector was determined, which was used to compute the frequencies. Y-axis = State & X-axis = Percentage.

Source: Authors own computation using data obtained from Companies Commission of Malaysia

3.5.3 Employment and Opportunities

For the chemical industry, there is a huge demand for highly qualified human resources. In response to the demand, the general outputs of knowledge workers are commendable and the supply of workforce is great. However, the quality of the workforce is still low. The chemicals industry is often headhunting highly skilled worker, especially chemical engineers, technicians and lab assistants. In the future, greater demand for highly qualified workers is expected. Therefore, there is an urgent need to increase the interest of young people in the field of science and technology. The ISB under their talent agenda is this matter seriously by engaging with the industry and education providers (S. Schneider, personal communication, October 8, 2015).

3.5.4 Challenges and Future

The aspiration of the state government is to prepare top-notch infrastructure and workforce in order to expand the specialty chemicals industry. Primarily strengthening the backward linkages of the specialty chemical segment with the existing eco-system. These initiatives are necessary because the greatest challenge for the chemical industry is R&D. Due to which the chemicals industry is missing their window of opportunity.

There is no stiff competition for the Malaysian chemicals industry in the ASEAN region. Therefore, Malaysia has to tap the international market quickly and effectively. Malaysia has the advantage of space and is able to tap a wider ecosystem. Currently, Malaysia requires a right body to strategically drive the agenda with the right policies in place. Primarily, the industrial parks and access to industrial gasses has to be at an international level. A matter of fact, there are many opportunities out there but many players are not going in and stepping up their game (S. Schneider, personal communication, October 8, 2015).

3.6 Summary

This chapter focused into the development and structure of the chemicals industry in Malaysia in general and Selangor in particular. The chemical manufacturing industry has transformed from a low performing sector to among the top manufacturing export sectors. For the State of Selangor, the chemical manufacturing industry is the backbone of the manufacturing sector as it has strong forward and backward linkages with other sectors. Additionally this sector offers high paying jobs. The state government is taking proactive steps to promote more investment into this sector by developing top-notch infrastructure and relevant try talents. The chemical manufacturing industry has the potential to be the leading player in the ASEAN region.

CHAPTER 4 : QUALITATIVE RESEARCH DESIGN

4.1 Introduction

The first objective of the qualitative study is to explore the EI determinants in the chemical manufacturing firms in Malaysia followed by refining holistic EI framework. The second objective is to gauge the state of the firms' EI initiatives. To achieve these objectives, at the initial stage, an in-depth literature search was conducted to identify the important determinants of EI and their dimensions. This information assisted in setting up of the preliminary hypothesis and conceptual framework, which is presented in Chapter 2.

In the second stage, the dimensions of each determinant are explored in the context of the chemical industry by using a case study method. This exploratory study enables the researcher to describe the processes involved in developing the capability, to churning EI specifically for the chemical industry. An additional purpose of this stage is to omit irrelevant dimensions, and include industry specific dimensions gauged through the interviews. Moreover, information from the interview will be used to determine important items for every dimension in order to develop a comprehensive questionnaire. This questionnaire will serve as an instrument to collect data from a larger sample of chemical firms.

This chapter explains the research design employed to complete the second stage of the qualitative study as explained. This chapter also discusses the qualitative aspects in conducting interviews such as trustworthiness, and the sampling frame.

4.2 Rational for Selecting Qualitative Approach

Qualitative approach was adopted due to several shortcomings related to this study. Initially, there is no single complete study, which can provide a holistic view of the determinants and mechanics of EI in developing countries (del Río et al., 2016). A more holistic approach to EI is necessary to align firms' existing technological capabilities, to effectively execute the EI initiatives (Cheng et al., 2014). To obtain a holistic view, qualitative enquiry is suitable because data exploration could be executed under real-world conditions, which are part of the daily routine of individuals. Over the years, these routines were amended to fulfill greater satisfaction, which is only possible through valuable experiences. The qualitative enquiry allows individuals to express their needs and wants based on the relevant service providers (Yin, 2011). Therefore, the rich input acquired from an industry setting is imperative to have a holistic view on EI that firms have embraced.

Next, gauging the environmental related information from firms is akin to indirectly asking about their commitments toward the environment. Information pertaining to firms environmental commitment is very intricate and sensitive (Kemp & Arundel, 2009; Scott, 1997). Participant may not directly reveal such information. Thus, qualitative enquiry allows the researcher to capture this valuable data (Yin, 2011). The ideas, real life examples, concepts and emotions that emerge during the interviews provide important supporting information to affirm or deny intricate and sensitive issues (Strauss & Corbin, 2008).

Finally, it is common for firms to keep their R&D and innovation information private and confidential, so that their ideas and designs are not expropriated (Rothwell, 1991; Scott, 1997). However, through qualitative inquiry, researchers are able to access this information, as they are directly engaging with the firms. One-to-one engagement increases the trust between the two parties and increases the comfort level between them. The strategy allows the researcher to convince the respondents that the information gathered is purely for research purpose and the confidentiality of the firm and interviewee is protected.

For reasons mentioned above, qualitative inquiry was deemed suitable, as it is more exploratory (Abu & Roslin, 2010; C. Anderson, 2010), and enable researcher to obtain substantive input from the firms (Strauss & Corbin, 2008). Moreover, scholars in the past, specifically in the area of environmental management have successfully used qualitative designs to gauge prominent and valuable information (Strannega, 2000; Tilley, 1999).

4.2.1 Multiple Case Study Strategy

A simple and carefully designed multiple case study approach strategy was adopted to explore the EI phenomenon in the firms. This approach was employed due to the complexity of dealing with environmental issues. The intricacy and sensitivity of environmental related information is based on (Kemp & Arundel, 2009), causing difficulty in data collection and analysis. A well-designed case study is capable of effectively exploring critical aspect of issues under the study. Case study approach have been frequently used especially for innovation related studies (Yin, Bateman, & Moore, 1985) and across various fields under the social science realm (Gibbert & Ruigrok, 2010).

This study is exploratory in nature as there is no clear indication of the determinations of EI and the mechanics that drives the EI initiatives for the case of chemical industry especially in the developing countries. Thus, studies under such constrains seek answer for “why” and “when” questions. Yin (2011) advised that when this is the situation a case study approach is the appropriate choice. Case studies are suitable to explore specific aspects of an organization (Noor, 2008). Furthermore, by using case study, the researcher is able to probe the specific aspects of the study to increase the richness of the data (Patton, 2002).

There are many types of case study. Stake (1995) suggested that three categories of case studies are as following:

1. Intrinsic case study: Researcher seeks a deliberate understanding of the case due to his curiosity towards the case. Lack of emphasis is placed on exploring a new construct and theory building. (Single case)
2. Instrumental case study: Researcher requires an in depth understanding of the case, which allows theory refinement. (Single case)
3. Collective case study: Researcher investigates multiple cases (more than one instrumental case study) to have a comparative understanding of a phenomenon or population for advanced theorizing.

This study fits into the first category. Intrinsic case study is similar to the category as proposed by Yin (2003), exploratory case study.

Multiple case studies are always suggested to be a better choice as compared to single case study (Yin et al., 1985). For the purpose of this study a multiple case study was perceived suitable for several reasons. First, EI is an evolving area of research; by having multiple cases, a comparison across cases is plausible to dictate the similarities and disparities. Second, it is easier to understand the pattern that is involved among firms to eco-innovate by using multiple cases. Next, Yin (2003) postulated that if the findings of the multiple cases follow a replicative pattern, then the results are considered robust. Therefore, this study employed a multiple case study approach taking into consideration the benefits of this approach on the final results.

According to Yin (2003), there is no single specific format to conduct a case study research. The main factor that a researcher need to given close attention is the clarity of the issue explored (Eisenhardt, 1989). The main issues this study intends to capture are related to the state of EI and building blocks of EI framework in the chemical firms. To ensure that these issues are carefully tackled, an interview protocol was developed (see Section 4.4.2.1.2).

Another critical aspect that needs to be monitored is data overload. If the interview questions are too broad, the case study is beyond the context of the study (Baxter & Jack, 2008). Certain boundaries a required to be ascertained to stay focus and avoid data overload (Yin, 2003). Therefore a preliminary conceptual framework was developed to carefully select the relevant EI determinants to be explored during the interview. The selected EI determinants are used as themes to develop the interview questions. However, if thriving issues are ascertained during the interview, certain levy is expected to occur. Propositions are not used in this study to guide the interview process, as there is lack of information (Yin, 2003) on the EI drivers for the chemical industry in Malaysia.

4.3 Trustworthiness and Rigor

Qualitative research is often evaluated using other criteria besides the quantitative evaluation criteria. Quantitative term like reliability and validity does not fit perfectly in the context of evaluating the rigor of qualitative case study (Krefting, 1991). Majority of qualitative research is conducted to derive hypothesis for the purpose of conducting an empirical research (Sandelowski, 1986). The reliability and validity of the research must be definite from the perspective of quantitative and qualitative approach. Quantitative interpretation of reliability and validity generally refers to the ability of an instrument to measure the intended purpose of the study. On the other hand, in the context of qualitative study, it refers to the ability to garner knowledge and understanding effectively pertaining to the subject matter, whereby, qualitative researchers are able to provide distinct and quality findings of the study (Krefting, 1991) (see Table 4.1). Therefore, for qualitative study, scholars suggested on assessing the trustworthiness of the findings (Guba, 1981; Lincoln & Guba, 1985). Lincoln & Guba (1985) emphasized four aspects of trustworthiness that are essential to provide credential to the findings, the aspects are as following: credibility, transferability, dependability and conformability. The following discussion is based on the text and knowledge of study by Lincoln & Guba (1985).

Table 4.1 : Comparison of criteria by research approach

Criterion	**Qualitative approach**	**Quantitative approach**
Truth value	Credibility	Internal validity
Applicability	Transferability	External validity
Consistency	Dependability	Reliability
Neutrality	Conformability	Objectivity

Source: Adopted from (Krefting, 1991)

Credibility refers to the level of confidence that researchers are able to exhibit in the findings. Data was collected from multiple sources: interview, business websites and annual reports. At the initial stage, the firm's business websites was thoroughly screened to ascertain the commitment towards mitigation of pollution. Several characteristics were used to assess the firm's environmental commitments such environmental compliance certification, environmental awards and compliance with foreign environmental standards. Possession of this information provided a benchmark to cross check the data collected during the interview. The level of commitment that firms portrayed matched the achievement of the firms. Annual reports were used to further solidify the information. The triangulation approach to increase credibility using multiple data sources (Yin, 2003) not only increased the truth-value but provided rigor to the study.

The next criterion proposed to assess trustworthiness is transferability, which refers to the suitability of the finding in a different context. A qualitative researcher should provide ample description and consistency in the findings, so that future studies are able to apply this information in a different context (Lincoln & Guba, 1985). This study deployed key informants method to ensure the breadth and depth of the issues are captured (Ashenbaum, Salzarulo, & Newman, 2012). This method allowed the preparation of detailed findings of the case, which encompasses important information pertaining to the phenomenon from a key informant perspective. Table 4.2 provides a concise profile of the firms that were interviewed. This background information could assist readers to apply the findings in similar situations.

Dependability is the third criterion, which assessed the extent a study to be replicated with the same sample or context. Lincoln & Guba (1985) claimed that by achieving credibility criterion is sufficient to ascertain dependability. This study employed a multiple case study approach. The goal is to explore similarities and differences within and between cases in terms of firm's environmental commitment. The findings were consistent across all the six firms that were interviewed. From case to case, the findings were replicable, which provided the basis for the achievement of the dependability criterion.

Ensuring that the findings are supported with the data collected from the qualitative approach adopted leads to the last criterion, which is conformability. Several steps were taken to avoid data loss and to preserve exact interpretation of a particular phenomenon during the interview. The steps are as following:

1. Taking notes during the interview.
2. Notes and interview information were immediately transcribed after interview.
3. Data was analyzed as soon as each of the respondents was interviewed.
4. A separate file and journal was kept to save the information either in hard and softcopy.
5. The interview information was discussed with peers to avoid any interpretation biasness.

Case study using variety of data sources was the prime builder of trustworthiness as it allowed effective data triangulation (Baxter & Jack, 2008). However, this would have not been possible with the preliminary conceptual framework and literature review that assisted in formulating reliable interview questions. This preliminary information also allowed the interview sessions to be more focused. Achieving credibility, transferability, dependability and conformability, therefore was not an issue.

Table 4.2 : Firm portfolio

Case context	A1	A2	A3	A4	A5	A6
Main product	Acrylic Monomer Oxo-Alcohols Butanediol & Derivatives	Propylene Diesel LPG	High quality fatty acids Glycerine Triacetin	Polymer Solvent Ethanol	Fatty alcohols Methyl esters Refined glycerine	Olefins & -Derivatives Polymer
Established year	997	1963	1980	1970	1983	1985
Total revenue	2.7 Million (2013)	14.6 Billion (2012)	3.2 Billion (2012)	1.5 Billion (2014)	1.1 Billion (2012)	6.0 Billion (2013)
Employees in 2013 (Domestic)	614	271	320	295	219	-NA-
Environmental commitment & Achievements	RCMS-Very comprehensive CICM RC award CICM gold award-Pollution Prevention Meeting foreign environment requirements	PMH award-Environmental and Social Performance Meeting foreign environmental requirements Globally Harmonized System (GHS) ISO14001	RSPO Certified RC Charter Renewable Chemical Award (International) RCMS ISO14001 REACH	Green Partner Status Certification Kaizen ISO/TS16949 Kiwa International Certification Meeting foreign environmental requirements	PMH award-Environmental Stewardship ISO140001 Meeting foreign environment requirements Globally Harmonized System (GHS) RoHS REACH	CICM RC award-Pollution Prevention PMH award-Environmental Performance Meeting foreign environment requirements REACH Chemical labeling
Informant	Senior Executive-Environment	Environmental Engineer	Engineer, HSE Department	Associate Manager - Handle environment issues	Senior Manager, HSE Department	Head, Environmental Management HSE

Note: RCMS=Responsible Care Management System, RC=Responsible Care, PMH=Prime Minister's Hibiscus Award, RSPO=Roundtable for Sustainable Palm oil

4.4 Population, Sample and Data

4.4.1 Population and Sampling

Large chemical manufacturing firms were selected for the purpose of the case study. In the case of Malaysia, policymaker's have dictated that large firms have the managerial capability and capacity to eco-innovate. The Malaysian National Environmental Policy indicated that large firms are purportedly able to facilitate small and medium enterprises through partnership schemes to eco-innovate (MOSTI, 2002). Nevertheless, the determinants and state of EI is unknown in these large firms. Thus, taking these factors into consideration and to avoid heterogeneity in terms of size, the large chemical firms were selected as subjects of this study.

Besides this prime reason, there are many other prominent reasons to select the large chemical manufacturing industry. Firstly, manufacturing industries consume a substantial share of the world's resources and constitutes significant portion of world's waste generation (OECD, 2009a). Due to this reason, the take on EI by manufacturing industries has greatly evolved over the years. Soaring participation of manufacturing industries in adopting cleaner production initiatives have attracted policy makers and researchers to further investigate this industry (OECD, 2009a). The potential to direct sustainable manufacturing and EI to greater heights and to drive sustainable society has been widely acknowledged. The industry has the capability to strategically integrate EIS for superior environmental performance (Maxwell, Sheate, & Vorst, 2006). The industry is also venturing into advanced approaches such as the product's lifecycle to reduce their environmental impact and developing own environmental management systems (Machiba, 2010). Due to these reasons the manufacturing industry is an interesting area to be explored.

Attention was given to only large manufacturing industries, as these industries are financially established and have better EI capabilities (Przychodzen & Przychodzen, 2015). This study aims to find better mechanism among these firms to conduct eco-innovation initiatives, as it involves a complex process (De Marchi, 2012; Zhu et al., 2010). Thus, there is a greater tendency to be proactively involved in EI activities (Aragón-Correa et al., 2008; Aragón-Correa, 1998).

Among the large manufacturing industries, the focus is on the chemical manufacturing industry. This is because the chemical manufacturing industry is highly polluting industry. The industry constitutes to dangerous amalgamation of hazardous substances and are at high-energy usage forefront. Moreover, this industry is claimed to discharge more harmful waste into the atmosphere as compared to other sectors (Anastas & Warner, 1998; Epicoco et al., 2014; Røyne, Berlin, & Ringstr, 2015). For these reasons, regulation for chemical industry is stricter (De Marchi, 2012) and requires more government support to promote EI. Lately, greening of the chemical industry has received huge attention. Chemical industry is expected to open doors for new sources of innovations. Companies with these new innovations are championing green chemistry in the future (van Hoof & Thiell, 2015).

Purposeful random sampling strategy was employed for case selection. Purposeful sampling techniques are deemed suitable as the case under this study is required to have a strong grasp of the central phenomena of the study (Baxter & Jack, 2008; Creswell, 2009). Firms were selected based on the following three main criteria. First, all the firms must be chemical manufacturing firms in Malaysia. Second, selected firms need to fulfill Malaysian large organization criteria, which is sales turnover of RM50 million and above or number of employees 200 and above (SMECorp., 2013). However, to ensure that very large firms were selected for this study, a minimum sales turnover of RM 1 billion and above was used and the number of employee criteria was maintained. Third, firms should posses certain level of environmental commitment such as ISO14001 certification, RCMS [7] , environmental awards, compliance with foreign environmental regulation and other relevant environmental commitment. Firms annual reports and website were used to obtain these information. Only firms with significant environmental commitment were considered, so that resourceful information can be gauged during the interview (Jabbour & Jabbour, 2009). The unit of analysis for this study is large chemical manufacturing firm.

List of chemical manufacturing firms was obtained from the Companies Commission of Malaysia through an online purchase. The contact information of the firms was then retrieved from the Federation of Malaysian Manufacturers Directory 2014 (FMM, 2014). The firms that met the above criteria were contacted through email, telephone and face-to-face meetings. They were briefly informed on the purpose of the interview. Next, an email was sent to the contact person assigned by the firms to provide details on the interview session. After several calls, emails and rejections six firms agreed to be interviewed. Due to sensitive nature of the research, the number of cases was increased to six firms, so that valuable insights can be obtained. Furthermore, Yin (2003) stated that under constrains, by adding the number of case can increase the degree of certainty. To preserve their anonymity, the firms were identified as A1, A2, A3, A4, A5 and A6. Table 4.2 provides a concise portfolio of all the firms.

[7] Responsible Care Management System (RCMC)

4.4.2 Data Collection Method

This case study utilized both, primary and secondary data collection method. Primary data collection method consists of interviews, while secondary data collection method consists of firm's business websites and annual reports.

4.4.2.1 Interview

For the purpose of this study, interview was finalized as the best method for data collection. This method allows the researcher to gauge information pertaining to firms environmental commitment as the information is sensitive an intricate in nature (Kemp & Arundel, 2009; Scott, 1997). To obtain such information, it demands a certain level of trust and reputation between the person who requires the information and the person providing the information. The researcher believed that through interview, reputation and trust can be built, thus, increases the confidence level of the interviewee to share sensitive and intricate information. Interview was necessary because there is a need to understand the mechanics and flow in the organization that brings together the resources and capabilities in order to eco-innovate. Thus, interviewing respondent in his own location provides a suitable environment to obtain the necessary information.

Finally, the researcher was positive on the decision to choose interview method, when most firms made several request prior to giving the consent to be interviewed. The requests are as following:

1. Recording was not permitted during the course of the interview.
2. The interview to be conducted in a short period as most of the officers from the environmental department is very busy.
3. Any specific documents or information will not be shared as it is presumed to be private and confidential during the course of the interview.

Based on these requirements, it was affirmed that firms' environmental commitment information is very sensitive and intricate; therefore, interview is the best method to obtain close to precise information.

A semi-structured interview method for data collection is employed. This method is suitable to explore informants' knowledge and perception towards complex issues and allow further probing for clarification (Louise Barriball & While, 1994) and to build internal validity. Furthermore, through semi-structured interview, a specific set of questions could be asked during the interview session, which allows probing to advance the inquiry (Harrell & Bradley, 2009). This technique helps in understanding the phenomenon better and allows the interviewee to provide prominent information.

A loose interview schedule was prepared based on carefully selected eco-innovation drivers that were dominant and budding in the research literature (Aira, Kauhanen, Larivaara, & Rautio, 2003). Interview protocol is presented in section 4.4.2.1.2. The interview lasted for an hour to an hour and half. The case study notes were written during the interview. To prevent data loss, therefore, a detailed report was prepared immediately after every interview session.

4.4.2.1.1 Key Informant

Personal face-to-face interview with key informant was conducted, as it is an effective mechanism to investigate beliefs and motives in dealing with various different issues. At the same time, non-verbal indicators allowed validation of this sensitive information, and increase the richness of the data (Louise Barriball & While, 1994; Robson, 2002; Smith, 1975; Sulaiman, Liamputtong, & Amir, 2014). Key informant's method also increased the reliability of the information as higher-level of insights are captured (Ashenbaum et al., 2012; Morse et al., 2008) and suitable when studying firm behavior (Seidler, 1974). For this study, the key informant was either the head or senior officer from their environmental or related department. Because, they are the main person who have all the knowledge related to firms' environmental initiatives (Bansal & Roth, 2000).

4.4.2.1.2 Interview Protocol

Introduction (3 minutes)	Thank you for giving your consent for this interview session. I'm Keshminder Singh from University Malaya, currently pursuing my PhD. The purpose of this interview is to meet my study objectives. My study deals with issues pertaining to pollution mitigation. Thus, I am looking into the initiatives that are taken by firms to coordinate their resources and capabilities to **generate practices and technologies** that reduce pollution and encourage resource conservation. These practices are commonly referred as cleaner production

	technologies or eco-innovation. Do you want me to enlighten on the term cleaner production/eco-innovation? For the purpose of this research, "you" or "your" is referred to the firm. All the information provided will be treated confidentially. Your name or any other information that has the potential to expose your identity will not be included in the report. Do you have any questions before I begin the interview?
Theme 1: Environmental Strategy (10 minutes)	1. To begin with, can you describe your initiatives to promote eco-innovation? 2. What are your own plan and action designed to achieve environmental goals? 3. From a scale of 1 to 5 can you rank the commitment of your organization to materialize these strategies? **Probe:** i. Who formulates these strategies? ii. How you measure the achievement of your strategies- i.e. Yardstick? iii. Is everyone involved in materializing these strategies? iv. Is there a specific department for environment? v. Do your merge your environmental strategies with your business strategies?
Theme 2: Market Pressure	4. Name main two market and non-market parties that pressure you to eco-innovate? **Probe:**

(5 minutes)	i. Which parties' pressure is given more attention? ii. In which specific area of environmental mitigation are you being pressured?
Theme 3: Export Orientation (5 minutes)	5. How do you respond to the environmental regulations/standards set by the countries that your export to? 6. Can you name three main regulations/standards set by them? 7. Name three countries, each with stringent and lax environmental regulation?
Theme 4: Environmental Knowledge (5 minutes)	8. Where do you get your information on eco-innovation? **Probe:** i. What type of eco-innovation information is important to you? ii. How is this information stored and managed in your organization?
Theme 5: Green Skills (5minutes)	9. How do you move your prepare your employees to eco-innovate? 10. Name three skills or trainings that you provide to them. **Probe:** i. Do you continuously update their knowledge? ii. How do you assess the level of their involvement?
Theme 6: Financial Resources (5 minutes)	11. Is there allocation for eco-innovation R&D? **Probe:** i. What is the percentage (% of TR)? ii. What is the funding channel?

Theme 7: Collaboration and Networking (5 minutes)	12. Who do you work with to eco-innovate? **Probe:** i. Are there parties outside your organization? ii. Why do you work with them?
Theme 8: Environmental Regulation (5 minutes)	13. How do you assess the enforcement of environmental regulation in Malaysia? 14. Is there any eco-innovation predominantly because of existing environmental policy? **Probe:** i. Is the environmental regulation stringent? ii. Is Malaysian environmental regulation more stringent compared to foreign environmental regulation? iii. If yes, which environmental regulation is influential? iv. How is the clarity and transparency of the regulation?
Theme 8: Eco-innovation (10 minutes)	15. What are the types of eco-innovation that your firm has done or doing currently? * A checklist was used to gauge these activities.
Final thoughts (2 minutes)	These are all the questions that I intend to ask. Are there any final thoughts on the subjects that we have discussed so far? Thank you.

4.4.2.2 Documented Resources

Two main sources of secondary data are firm's business websites and annual reports. Secondary data collection methods were used for three reasons. For sampling purposes, at the initial stage, so that the firms that are selected has a certain degree of environmental commitment. This was necessary to obtain fruitful information during the interview sessions. Information pertaining to firm's environmental commitment is reflected through the environmental compliance clarification is obtained to ascertain their commitment to international environmental treaties/standards and environmental compliance awards received.

Next, the large firms selected had well-established websites and detailed annual reports that reported a chapter separately regarding their environmental activities. This information assisted in supporting and triangulating the interview data to ensure the trustworthiness of the information. Finally, the information extracted from the secondary data sources helped in shaping this study in the context of understanding the current eco-innovation landscape in Malaysia, shaping the interview protocol and analyzing the findings.

4.4.3 Data Analysis Method

Data analysis was conducted qualitatively using content analysis and a thorough exercise of categorization (Elo & Kyngäs, 2008; Krippendorff, 2004). The categorization process was easier as the interview questions were structured according to specific themes based on predetermined EI determinants based on the available literature. For emerging findings, however, an open axial and selective coding producers were used to generate themes, and proceed to categorization (Strauss & Corbin, 2008). Finally, link between the categories were constructed and validation of the dimensions established was justified by making cross reference between statement by respondents, firms web information, annual reports and EI literature (Abu & Roslin, 2010; Jabbour & Jabbour, 2009; Lozano, 2015).

4.5 Summary

This chapter presented a detail research methodology to obtain a more holistic view of complex environmental issues. A case study approach was employed as it allows a better discovery of the EI phenomena. Taking into consideration the sensitivity and the complexity of environmental data, this approach is proposed to strongly unveil such information through the participant layer of analysis. Moreover, in this chapter, matters on how the study was executed and detailed information on the sampling criteria, interview protocol and trustworthiness of the findings were explained. The interview findings and the finalized conceptual framework are discussed in the following chapter.

CHAPTER 5 : QUALITATIVE FINDINGS

5.1 Introduction

The main purpose of this chapter is to explore the determinants of EI (Objective 1) in the chemical manufacturing firms in Malaysia and to refine a holistic EI framework that is industry specific (objective 2). The key issues examined are this chapter is as follows:

1. What is the state of eco-innovation in the chemicals manufacturing industry?
   - i. Are the firms introducing all three types of EI (i.e., process, product and organizational)?
   - ii. What is the intensity of the EI (i.e., creation and adoption)?
   - iii. How does the introduction of EI differ according to ownership type (i.e., foreign and domestic), headquarters location (i.e., foreign and domestic) and foreign export destinations (i.e., to stringent and lax environmental regulation export destination)?
   - iv. What are the sustainable manufacturing concepts and practices that firms have embraced?
2. What should be the best integrated framework to drive eco-innovation in the chemical manufacturing industry?
   - i. How are the predetermined EI determinants relevant in chemical manufacturing firms in Malaysia?
   - ii. How are these EI determinants linked to EI?
   - iii. Are there any other pertinent EI determinants that require further attention?

iv. How is the entire organization framed to eco-innovate?

v. What are other important organizational issues pertaining to EI?

5.2 State of Eco-innovation (Objective 1)

It is imperative for a country to measure the state of EI, as the concepts and practices of sustainable manufacturing are evolving overtime. To achieve the state of green utopia, economies are required to move away from EIs that merely treat pollution and embrace EIs that synergies industrial ecology (see Figure 2.2). Therefore, determining the overall trend and practices in EI (i.e., creation, adoption, increasing, decreasing and transition such as from pollution control to lifecycle thinking) is important for policy makers, business managers and several other stakeholders.

Responding to the call from the literature, and by considering Malaysia's more than 40 years of experience dwelling with environmental policies, there is an urgent need to investigate the state of EI in Malaysia. For the purpose of this study, as mentioned earlier, the focus is only on process EI, product EI and organizational EI. During the interview sessions, informants were inquired on the type of EI undertaken or currently commissioned. Moreover, to generate more information, the interviewees were asked whether those EIs were creation or adoption. To avoid confusion, at the initial stage, informants were clarified on the term creation and adoption. Creation is referred as newly developed and utilized EI by firms that replaced or complemented the existing EIs (Altmann, Rundquist, & Florén, 2011). Adoption is referred as deploying EI, which is readily available in the market and to an extent customized this innovation to suit their production and process specification (Khanna, Deltas, & Harrington, 2009).

Classification of EI by Kemp & Pearson (2007), in their study on measuring EI was used as a checklist to obtain and analyze information pertaining the state of EI in the firms. Besides qualitative data on the state of EI gathered during the interview, quantitative data was also collected (i.e., 97 firms responded to the survey questionnaire).

From the survey data, the introduction of EI by firms was divided according to three aspects, namely: firm's ownership type (i.e., domestic, foreign and state), headquarters location (i.e., domestic or foreign) and export destination (i.e., to countries with stringent or lax environmental regulation). This enabled the researchers to examine the impact of these aspects on the introduction of EI. To increase the robustness of the findings, both the qualitative and quantitative findings regarding the state of EI is presented in this chapter.

5.2.1 State of EI in Process, Organizational and Product EI Category

This section entirely focuses on the introduction of EI by 97 chemical manufacturing firms in the process, product and organizational EI category. Additionally, this section indicates the percentage of EI introduced from 2010 to 2015 through adoption and creation. The qualitative results for the state of EI in chemical manufacturing firms are presented in Table 5.1.

From all the six types of EI in the process eco-innovation classification, EP1 is the major process EI introduced during the period of 2010 to 2015 with 69.1% of firms accounting for it. Followed by EP2, EP3 and EP4, where for each innovations, an average of 55.0% of firms acknowledged introducing these process EIs. The aforementioned process EIs are among the required pollution mitigation technologies under the Malaysia Environmental Quality Act, 1974. The results indicate that over the years firms have continuously invested in these mandatory technologies. Firms highlighted that their investment into this type of innovation is primarily to reduce waste generation and promote higher energy efficiency. Furthermore, firms are employing advanced technologies and solutions to replace or improve the existing capacity.

Table 5.1 : State of EI in Chemical Manufacturing Firms

	During the five years, from 2010 to 2015, did your enterprise introduce any new or significantly improved of the following:	**Yes** (%)	**No** (%)	**Adoption** (%)	**Creation** (%)
EP1	Cleaning technology that treat pollution released into the environment: Pollution control technologies for air, water & soil (Scrubbers/dust collection system/waste water treatment)	69.07	30.93	73.13	26.87
EP2	Cleaner process technologies: New manufacturing processes that are less polluting and/or more resource efficient than relevant alternatives	56.70	43.30	78.18	21.82
EP3	Waste management technologies/equipment's (Incinerators/recycling equipment)	52.58	47.42	86.27	13.73
EP4	Environmental monitoring technologies and instrumentations	55.67	44.33	88.89	11.11
EP5	Noise and vibration control technologies	41.24	58.76	87.50	12.50
EP6	Green energy technologies (solar/wind/bioenergy)	24.74	75.26	87.50	12.50
EO1	Pollution reduction/prevention schemes that address source reduction, reuse and recycling, and energy consumption: Which eliminates wasteful management practices	70.10	29.90	60.29	39.71
EO2	Formal systems of environmental management involving measurement and reporting. For example ISO 14001, EMAS and other	53.61	46.39	71.15	28.85
EO3	Chain management: cooperation between companies so as to close material loops and to prevent environmental damage across the value chain	42.27	57.73	53.66	46.34
EPR1	New environmentally improved products or services for end users	53.61	46.39	55.77	44.23
EPR2	Products that will have lower emissions when used	44.33	55.67	53.49	46.51
EPR3	Products that are more energy efficient	47.42	52.58	56.52	43.48

Note: Process Eco-Innovation (EP): EP1–EP6, Organizational Eco-Innovation (EO): EO1–EO3, Product Eco-Innovation (EPR): EPR1–EPR3
Source: The list of EIs was adapted from Kemp & Arundel (2009).

For green energy technology (EP6), 75.3% of firms indicated that they are still heavily dependent on non-green energy technologies, despite clean energy source has been an important agenda for the top management for a long time. However, few firms responded that they are using green energy source from methane and steam, which is generated from their byproducts/waste (i.e., IETS/WWTP, H2Richoffgas). From the data, it is evident that most of the processed EI are adoption. Interviews revealed that adopting these technologies is a better option, as it is cheaper and readily available. On the other hand, a small fraction of creation is taking place, but to a large extent it complements the existing technologies.

> *"For now we prefer adoption, its much cheaper and readily available. In- house process innovations do take place and most of these innovations complement the existing technologies that we have."(Respondent A3)*

The next classification of EI, which has gained a lot attention from firms, is organizational EI. During the interview, firms expressed that organizational EI is imperative to increase their environmental performance in the long-term. Since, the environmental management and pollution prevention system assisted to integrate every effort, resources and capabilities required to solve environmental problems. With such system in place, the identification and rectification of environmental issues is more effective and is easier for the top management to monitor the achievement of the environmental strategies. The results indicated that 70.1% of firms introduced pollution prevention schemes (EO1) for the duration of 2010 to 2015, and 53.6% of firms employed formal environmental management systems (EO2) during the five years. For EO1, even though the adoption (60.3%) is greater than creation (39.7%), but a significant number of firms are developing their own pollution prevention schemes. For EO2, however, the results indicated otherwise. Furthermore, firms indicated that adoption of EO was necessary at the initial stage, as it provides some idea and *'technical know-how'* before they independently develop their own organizational EIs.

"For us there are carefully administered environmental management schemes and plans, because the business that we are in there is no room for mistakes. These systems integrate every aspect of environment, which automatically makes the execution and monitoring of environmental goals much easier…we adopt the existing ones here and there, but we have our very own structure". (Respondent A4)

Interestingly, besides EO1 and EO2, firms are seriously venturing into chain management (EO3) to reduce their carbon footprint. Firms indicated that they are going to greater lengths from involving their suppliers and vendor to close material loops throughout the supply chain. They believed that this is necessary due to two reasons. First, there is an increasing pressure from their trading partners, as stringent environmental standards are imposed on almost every process of chemical manufacturing. Second, to remain competitive there is a need to look at emerging environmental issues, which is currently the chain management. In the five-year period, 42.3% of firms have introduced EO3, with 53.7 % through adoption and 46.3% through creation. Notably, as chain management is an emerging issue, almost 50% of the firms has created their own mechanism to tackle this issue.

"We have started working on chain management very seriously now. Realization among companies is there, that looking into this area rewards long-term sustainability…procedures and mechanism are there in place to close material loops throughout the supply chain but with new emerging issues and requirements from trading partners more need to be done". (Respondent A1)

"We have our own system, which takes into account every single thing that we do. This systems allows us to track problems …besides internal environmental management we do manage our suppliers, which is a larger requirement under our green bending procedures. Before we accept any vendor, we thoroughly audit them first. In fact, we even audit 'Kualiti Alam' (Malaysia's integrated waste management company)". (Respondent A2)

The third classification of EI, which consumes the largest share of their R&D allocation as compared to process EI and organizational EI is product EI. The increase stringency of environmental standards imposed on chemical products locally and internationally is the main reason for the rise in EI products. Furthermore, there is a huge demand for Malaysian chemical products as it complies with major international environmental standards and is applauded for its high quality. Thus, to retain the market share and to remain competitive, their products must exhibit environmentally friendly features. Considering all these factors, firms have constantly upgraded their R&D facilities and searched for advanced solutions and materials to improve their products. In addition, both have embraced product lifecycle approach to reduce the ecological impact from using their products. Firms were asked about three aspects of green products that they have introduced during the period of 2010 to 2015.

The first aspect was intended to generally capture if there is any introduction of new environmentally improved products or services for end users (EPR1) by firms. While the second and third aspects was used to capture the introduction of more product specific features, lower emission (EPR2) and energy efficiency (EPR3). For the five years duration, the statistics shows that 53.6% of the firms introduced new environmentally improved products and services (EPR1). In terms of specific environment friendly product features, 44.3% of firms indicated the introduction of products with lower emissions (EPR2) and 47.2% indicated introduction of products with higher energy efficiency (EPR3). For both EPR2 and EPR3, on average 55.0% is through adoption and 45.0% is by creation. In comparison to process EI and organizational EI, there is greater level of creation involved for product EI.

"Taking into account the stringent environmental standards in overseas and Malaysia and also the huge market for our chemical products, we conduct greater product related R&D. Malaysian chemical products are of good quality and we comply with all the international standards. To protect our market, green chemical products are important." (Respondent A3)

"Our facilities are upgraded to conduct product related research. Over here, we use product life cycle approach... There is tough competition out there, to survive we have to follow the trend." (Respondent A4)

5.2.2 State of EI According to Firm's Headquarters Location, Ownership and Export Destination

This section explores the state of EI further by engaging the EI data from three different aspects, namely firm's headquarters location, firm ownership and export destination. For each of the aspects, the percentage of the average number of firms that introduced EI from 2010 to 2015 for all the 12 types of EIs (EP1 – EPR3) (i.e., as shown in Table 5.2) was computed. The purpose of this section is to determine the implication of foreign influence on EI initiatives in Malaysia.

Table 5.2 : State of EI According to location of Headquarters, Ownership and Export Destination

	% of Firms Introduced EI (2010-2015)	**Adoption** (%)	**Creation** (%)
	Headquaters		
Foreign	55.11	60.49	39.51
Domestic	48.99	75.77	24.23
	Ownership (51% and above)		
Domestic	46.99	77.62	22.38
Foreign	58.06	59.26	40.74
State	55.00	69.70	30.30
	Export Destination (Environmental Regulation)		
Stringent	53.48	64.59	35.41
Lax	47.62	79.17	20.83

Note: The figures indicate the percentage of average number of firms that introduced EI for all the three types of eco-innovations (Process E1: EP1–EP6, Organizational EI: EO1–EO3, Product EI: EPR1–EPR3) during 2010-2015.Total number of firms = 97 (domestic owned = 61, foreign owned = 31, state owned = 5)

5.2.2.1 Firm's Headquarters Location

Based on firm's headquarters location, firms with foreign headquarters (FHQ) indicated a greater average percentage of EI introduction for all 12 types EIs (see Table 5.1) as compared to firms with domestic headquarters (DHQ) by 6.1% (see Table 5.2). While firms with FHQ greatly introduced majority of the EIs during 2010 to 2015 as compared to DHQ. There were five types of EIs that firms with DHQ showed a marginally higher introduction. They are EP4 (environmental monitoring technologies and instrumentations), EP5 (noise and vibration control technologies), EO2 (formal environmental management systems), EO3 (supply chain management) and EPR3 (products that are more energy efficient), which exhibit marginally higher percentage of introduction than firms with FHQ by 1.2%, 3.7%, 2.9%, 0.5% and 12.8% respectively (see Table 19). EP4, EP5 and EO2 are fundamental types of EIs, which are presently deemed mandatory to mitigate pollution, while EO3 and EPR3 are advanced types of EIs, which look into more critical aspects of pollution mitigation. Among all the five EIs, firms with DHQ were seen greatly focusing on the introduction of product related EI (EPR3). On the other hand, firms with FHQ were seen greatly focusing on the introduction of process related EI especially EP1 (cleaning technology that treat pollution released into the environment) and EP2 (cleaner process technologies: new manufacturing processes) at 80.1% and 67.7% respectively (see Table 5.3).

In terms of the intensity of EI, both firms with FHQ and DHQ exhibited higher average percentage of adoption as compared to creation (see Table 5.2). However, firms with DHQ recorded 15.3% higher average percentage of adoption as compared to firms with FHQ. The highest percentage of adoption for firms with DHQ and FHQ was for process related

EIs (EP1 – EP6) (see Table 5.3). Among the process related EIs, firms with FHQ were seen adopting greater green energy technologies (EP6) as compared to firms with DHQ. On creation front, firms with FHQ projected higher average percentage of creation as compared to firms with DHQ, 39.5% and 24.2% respectively (see Table 5.2). The highest percentage of creation for both locations was from product related EIs. Besides product related EIs, firms with FHQ recorded a high percentage of creation for pollution reduction/prevention schemes (EO1) that falls under organizational EI category.

Table 5.3 : State of EI According to Firm's Headquarters Location

	% of Firms Introduced EI (2010-2015)		Domestic		Foreign	
EI	**Domestic (%)**	**Foreign (%)**	**Adoption (%)**	**Creation (%)**	**Adoption (%)**	**Creation (%)**
EP1	63.64	80.65	78.57	21.43	64.00	36.00
EP2	51.52	67.74	85.29	14.71	66.67	33.33
EP3	51.52	54.84	88.24	11.76	82.35	17.65
EP4	56.06	54.84	89.19	10.81	88.24	11.76
EP5	42.42	38.71	92.86	7.14	75.00	25.00
EP6	21.21	32.26	85.71	14.29	90.00	10.00
EO1	68.18	74.19	71.11	28.89	39.13	60.87
EO2	54.55	51.61	72.22	27.78	68.75	31.25
EO3	42.42	41.94	57.14	42.86	46.15	53.85
EPR1	42.42	77.42	64.29	35.71	45.83	54.17
EPR2	42.42	48.39	60.71	39.29	40.00	60.00
EPR3	51.52	38.71	64.71	35.29	33.33	66.67

Note: The figures indicate the percentage of the number of firms that introduced each of the EI types according to their headquarters location. Number of firms with domestic headquarters location = 66 & Number of firms with foreign headquarters location = 31.

5.2.2.2 Firm Ownership

Under the firm ownership domain (i.e., 51% and above), the three ownership types, domestic, foreign and state were apparent. From the 97 firms, 61 firms had domestic ownership (DOW), 31 firms had foreign ownership (FOW) and 5 firms had state ownership (SOW). For the period of 2010 to 2015, among the three ownership types, Firms with FOW exhibited highest average percentage of EI introduction followed by SOW and DOW at 58.1%, 55.0% and 47.0% respectively (see Table 5.2).

While firms with FOW greatly introduced majority of the EIs during 2010 to 2015 as compared to DWO, there were two types of EIs that firms with DWO showed a marginally higher introduction. They are EP5 (Noise and vibration control technologies) and EPR3 (products that are more energy efficient) (see Table 5.4), where this situation is similar to firms with domestic headquarters as discussed earlier. Firms with SOW being the second largest introducer of EIs during the five-year duration registered higher EI introduction for six types of EIs as compared to firms with FOW and DOM. The EIs are EP3 (waste management technologies/equipment's), EP4 (environmental monitoring technologies and instrumentations), EP5 (noise and vibration control technologies), EO2 (formal environmental management systems), EO3 (supply chain management) and EPR3 (products that are more energy efficient) with an introduction rate of 80.0%, 80.0%, 60.0%, 60.0%, 60.0% and 60% respectively. From the statistics it was evident that the types of EIs that are introduced by firms with domestic headquarters, domestic ownership and state ownership, which are greater in percentage as compared to firms with foreign headquarters and ownership are somewhat similar. Therefore, firms, which are domestically affiliated, seem to have a similar EI agenda.

Next, looking into the intensity of EI from firm's ownerships perspective, the statistics indicated that firms under all the three types of ownership are net adopters. Firms with highest average percentage of adoption are the ones with DOW followed by SOW and FOW at 77.6%, 69.7% and 59.3% respectively (see Table 5.2). Furthermore, the rate of adoption for all the three ownership types is highly concentrated in the process (EP1 –EP3) and organizational EI (EO1 – EO3) category. On the EI creation platform, firms with FOW are leading the race with 18.4% and 10.4% higher than firms with DOW and SOW accordingly. Even though firms with FOW headed creation of EI for majority of the EI types, firms with SOW have indicated greater percentage of introduction for the product EI category (EPR1 – EPR3) (see Table 5.4). Similarly, creation for firms with DOW, even though smaller than firms with DOW, records a higher percentage in this category as compared to process and organizational EI category. Furthermore, firms with DOW indicated higher percentage of green energy technology (EP6) creation as compared to firms with FOW by 5.38% (see Table 5.4).

Table 5.4 : State of EI According to Firm Ownership

	% of Firms Introduced EI			Domestic		Foreign		State	
EI	**Domestic (%)**	**Foreign (%)**	**State (%)**	**Adoption (%)**	**Creation (%)**	**Adoption (%)**	**Creation (%)**	**Adoption (%)**	**Creation (%)**
EP1	59.02	87.10	80.00	77.78	22.22	66.67	33.33	75.00	25.00
EP2	49.18	70.97	60.00	86.67	13.33	68.18	31.82	66.67	33.33
EP3	49.18	54.84	80.00	96.67	3.33	70.59	29.41	75.00	25.00
EP4	52.46	58.06	80.00	93.75	6.25	83.33	16.67	75.00	25.00
EP5	42.62	35.48	60.00	96.15	3.85	72.73	27.27	66.67	33.33
EP6	21.31	32.26	20.00	84.62	15.38	90.00	10.00	100.00	0.00
EO1	68.85	74.19	60.00	66.67	33.33	43.48	56.52	100.00	0.00
EO2	52.46	54.84	60.00	71.88	28.13	64.71	35.29	100.00	0.00
EO3	37.70	48.39	60.00	56.52	43.48	46.67	53.33	66.67	33.33
EPR1	44.26	77.42	20.00	70.37	29.63	41.67	58.33	0.00	100.00
EPR2	39.34	58.06	20.00	66.67	33.33	38.89	61.11	0.00	100.00
EPR3	47.54	45.16	60.00	65.52	34.48	42.86	57.14	33.33	66.67

Note: The figures indicate the percentage of the number of firms that introduced each of the EIs according to domestic, foreign and state ownership. Number of firms with domestic ownership = 61, firms with foreign ownership = 31 and firms with state ownership = 5

5.2.2.3 Firms Export Destination

The last aspect, which is used to explore the state of EI, is firms export destination. Firms export destination was divided into two, one with stringent environmental regulation and one with lax environmental regulation. During the interviews firms were required to provide a list of countries, which imposed stringent and lax environmental regulation on their exports (see Figure 5.5). This list was further refined and calibrated with the environmental regulatory regime index (ERRI) score that ranked countries based on the quality of their environmental regulation system (Esty & Porter, 2001). During the Web survey firms were required to list two countries where their major export was headed. The country information was then coded ‘1’ for stringent environmental regulation export destination (SERED) and ‘0’ for lax environmental regulation export destination (LERED).

According to firm’s export destination, firms that exported to SERED showed a higher average percentage of EI introduction as compared to those who exported to LERED by 5.9% (see Table 5.2). While firms with SERED introduced majority of the EI types at a higher percentage during 2010 to 2015 as compared to firms with LERED, three types of EIs was headed by firm with LERED. All the three EIs was from the process EI category namely: EP3 (waste management technologies), EP5 (noise and vibration control technologies) and EP6 (green energy technologies) which recorded 3.9%, 11.3% and 6.8% (see Table 5.5) respectively higher as compared to percentage of introduction by countries with SERED. Additionally, even though lower than firms with SERED, firms with LERED exhibited high introduction in the organizational EI category (EO1 – EO3).

Table 5.5 : State of EI According to Stringent and Lax Environmental Regulation Export Destination

EI	% of Firms Introduced EI		Stringent Regulation		Lax Regulation	
	Stringent (%)	**Lax (%)**	**Adoption (%)**	**Creation (%)**	**Adoption (%)**	**Creation (%)**
EP1	76.36	59.52	73.81	26.19	72.00	28.00
EP2	60.00	52.38	75.76	24.24	81.82	18.18
EP3	50.91	54.76	78.57	21.43	95.65	4.35
EP4	60.00	50.00	87.88	12.12	90.48	9.52
EP5	36.36	47.62	80.00	20.00	95.00	5.00
EP6	21.82	28.57	91.67	8.33	83.33	16.67

Table 5.5 : State of EI According to Stringent and Lax Environmental Regulation Export Destination - continue

EI	% of Firms Introduced EI		Stringent Regulation		Lax Regulation	
	Stringent (%)	Lax (%)	Adoption (%)	Creation (%)	Adoption (%)	Creation (%)
EO1	74.55	64.29	48.78	51.22	77.78	22.22
EO3	43.64	40.48	50.00	50.00	58.82	41.18
EPR1	63.64	40.48	45.71	54.29	76.47	23.53
EPR2	49.09	38.10	40.74	59.26	75.00	25.00
EPR3	50.91	42.86	46.43	53.57	72.22	27.78

Note: The figures indicate the percentage of the number of firms that introduced each of the EIs according to stringent and lax export destination. Number of firms exporting to stringent environmental regulation destination = 55 & firms exporting to lax environmental regulation destination = 42

Next, engaging the data with the intensity of EI exhibited by firms with SERED and LERED revealed that firms with exports to both the destinations have higher average percentage of EI adoption as compared to creation each at 64.6% and 79.1% respectively (see Table 5.2). Both the export destination recorded high percentage of adoption for the process (EP1 – EP6) and organizational (EO1- EO3) EI category (see Table 5.5). However, for the product EI category firms with LERED exhibited higher percentage of adoption as compared to firms with SERED. Where each of the EIs in this category registered a difference of 30.8% (EPR1), 34.3% (EPR2) and 25.8% (EPR3) respectively (see Table 5.5) against percentage of adoption by firms with SERED. For the facet of EI creation, firms with SERED are having the upper hand at an average percentage of 35.4% as compared to LERED at 20.8% (see Table 5.2). Firms exporting to both destinations especially for the organizational (EO1 – EO3) and product (EPR1 – EPR3) EI category exhibited higher percentage of creation. For all the six EIs mentioned earlier in both categories, firms with SERED supersedes with high percentage difference for majority of the EI as compared to firms with LERED. Among the significant wants are EO1 (pollution reduction/prevention schemes), EPR2 (products with lower emissions) and EPR3 with a percentage difference of

29.0%, 34.3% and 25.8% accordingly (see Table 5.5). However, among the organizational EI category firms with LERED contributed to a greater creation for EO2 (formal system of environmental management) as compared to firms with SERED at 31.8% and 26.7% respectively. From the data it is evident that both the export destination places greater pressure for firms to eco-innovate in the organizational and product EI category.

5.3 Eco-Innovation Framework and Determinants (Objective 2)

The sector specific EI framework developed from the interview findings consists of three sub-models namely: resource model (model 1), strategy model (model 2) and eco-innovation model (model 3). To provide a better understanding of each EI determinants in each sub-models, and how all the three sub-model are integrated to structure the entire EI framework, findings for each sub-models are presented individually in this section.

5.3.1 The Resource Model (Model 1)

This section focuses on the three technology push factors: environmental knowledge, environmental collaboration and green skills to determine the resource model EI.

5.3.1.1 Environmental Knowledge

The interview data firmly supports that firms heavily depend on the environmental knowledge to achieve their environmental objectives. In response to the interview data, two core areas of knowledge that firms constantly explore and update are related to technology and hazardous chemicals. Technology related information is concerning waste reduction, increasing energy efficiency and carbon calculation. Whereas, information relating to hazardous chemical is pertaining to the volatile organic compound (VOC).

Firms used this information to set up their environmental knowledge databases. These databases become the entry point for firms to obtain technical and fundamental knowledge in solving their environmental issues. The main purpose for firms to compile this information is to identify and design latest training modules for their employees. The knowledge databases are frequently referred to disseminate current environmental knowledge to employees. The knowledge acquired was proven to promote environmental awareness and inculcate environmental commitment behavior generally within the organization and specifically among the employees. As a result, employees are equipped with skills that are critical to solve current burgeoning environmental issues. From the discussion above, it is evident that environmental knowledge unleashes employee's green skills.

Besides promoting green skills among employees, this knowledge also contribute in designing firm's environmental strategy. There is a chain effect; well-trained employees are equipped with sound green skills and high environmental commitment values. The employees then with the support from the top management who are embodied with positive behavior protect the environment generate valuable idea to solve environmental issues. Later, these ideas transpire into firm's environmental strategies. Therefore, based on the respondent's feedback, there seem to be an indirect effect between the environmental knowledge and environmental strategy through employee green skills.

"To solve environmental related issues, we capitalize on the information that we obtain from all our sources. We have our very own database that stores all the information, which is used by staff/departments. Information related to latest technology is always important to us, and currently we are searching for advanced techniques for carbon calculation." (Respondent A2)

"Safety committee is responsible to search for all the information required to achieve our targets. Most of the time we are looking for Information on technology, hazardous chemicals (VOC) and waste reduction." (Respondent A6)

"Continuous information flow helps us to develop and update our own training modules, so that we can provide necessary skills to our employees, especially to solve critical environmental problems." (Respondent A1)

"The stock of knowledge is used by managers and technical teams to expedite their projects…for example, increasing the energy efficiency" (Respondent A4)

The interaction with the responds in exploring the determinant environmental knowledge did not indicate any direct relationship with EI. The environmental knowledge from firm's perspective is resources that enable them to train their employees, boost firms environmental awareness and generate strategies to solve environmental problems.

5.3.1.1.1 Environmental Knowledge Channels

Firms indicated that there are several channels used to access environmental knowledge. The leading channel is their group[8] (See Figure 5.1). The group has a structured and robust database, which provides both paramount technical and non-technical information to the firms.

"The information here is centralized. Professional and technical expertise is available in the group." (Respondent A2)

[8] The group centralized by the headquarters, consists of business units, subsidiaries, joint ventures, global partners and important affiliates.

"All the information obtained from the group, which has a structured system to collect and store information. All the technical information is from the group." (Respondent A5)

"Group provides all the critical information." (Respondent A4)

Research, conferences, exhibitions, peers and suppliers are another set of key avenues where firms obtain their environmental information. It is important to note that suppliers are the main external party that firms frequently interact. Moreover, said the external parties have the relevant information that the firms need especially technology related.

"We always deal with suppliers. These people are very important for us because they provide us information on the latest technology available." (Respondent A3)

"Suppliers have all the information. When it comes to business, we cannot run away from them. They always bring their booklets and brochure…mostly technology related information. From them we get to know exhibitions that are taking place." (Respondent A4)

Other active channel is the DOE/DOSH, which provides more regulatory and environmental compliance information and followed by experts, who provide professional advice through casual discussions or consultancy services. The last medium is through online search carried out independently.

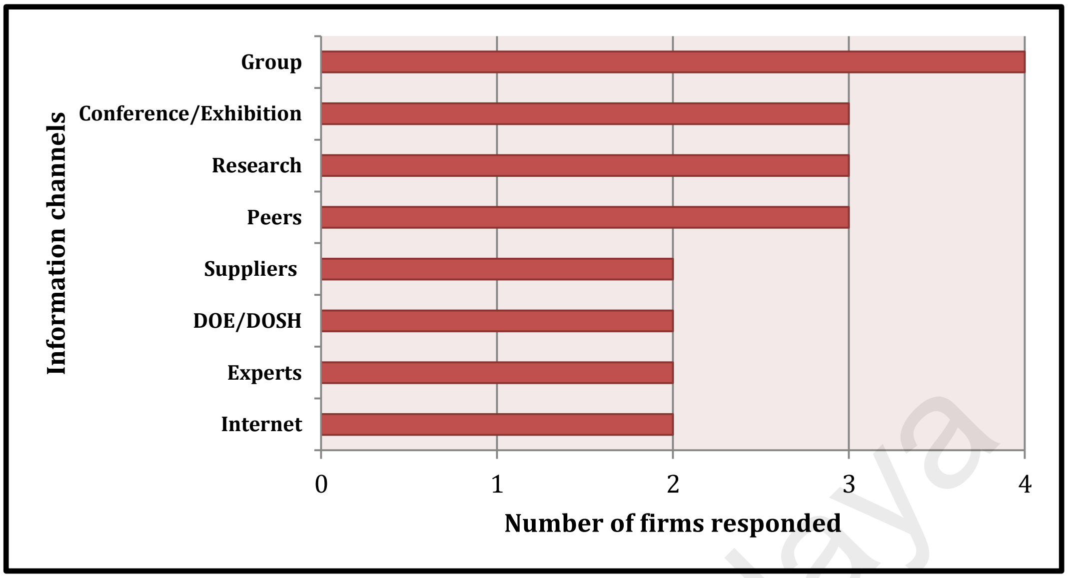

Figure 5.1 : Information channels
Note: Total number of firms interviewed = 6 (6 respondents). Data generated from the interviews.

5.3.1.2 Environmental Collaboration

Firms recognize collaboration as an important channel to groom employees and formulate environmental strategy. This is possible because collaboration creates opportunities for firms to venture into training employees and to structure environmental strategy. Among the opportunities created are wider network, which allows better understanding of environmental issues that are taking place globally and solutions to tackle these environmental issues. Next, it provides an easy route for firms to find immediate solution through best practices and meaningful information shared by others, which saves time and money. Furthermore, collaborations allow benchmarking among peers, through which firms gauge their current environmental commitments to improve their competitive position.

> *"Networking/collaboration widens our horizon because firms either from local or international platform have a different way of solving their environmental issues. Sharing best practices among organizations is trending nowadays, which, is a noble deed. This initiative can bridge the gap between know-what and know-how." (Respondent A3)*

"Through collaboration we benchmark ourselves, to see where we stand and what can we do to improve. The information that we obtain helps us to strategize. Organizations cannot side line the environment anymore, it has to be part of their main goals, especially to survive in the current business settings."(Respondent A4)

"To build trust, collaboration and networking is very important. This trust in return, eases the process of sharing resourceful knowledge and expertise. Solving environmental problem has to be through a collaborative effort as we are able to influence as many parties as possible to adopt sustainable manufacturing practices." (Respondent A1)

Table 5.6 : Reasons and outcomes of collaboration

Reason for collaboration	Number of firms responded	Outcome
Information/Knowledge	√√√√√√	-Training modules -Technology updates
Expertise	√√√√	-Impetus of green products -Strategic environmental planning
Sharing best practices	√√√	-Fast solution (save cost, time & resources) -Being socially responsible
Benchmarking	√	-Keep up with recent green changes & progress -Self-evaluation compared to peers
Influence	√	-Increase in power of persuasion. Convincing top management to undertake environmental projects

Note: Total number of firms interviewed = 6 (6 respondents). Data generated from the interviews.

The opportunities discussed above assisted firms to create training modules for employees. There is a lot of rigor in these modules as it is the outcome of resourceful knowledge accumulated from the sharing of best practices, expert opinions and benchmarking with peers. Next, these opportunities provided avenues for firms to design their environmental strategies with reference to the current scenario of environmental issues. Designing these strategies was much easier as there are ample solutions to mitigate environmental problems and information on the latest eco-innovations. Finally, collaboration increased the motivation of the firms to be environmentally responsible. Table 5.6 summarizes five main reasons for firms to collaborate, including the outcome of those collaborations.

In addressing the environmental problem, environmental collaboration proved to be an essential resource provider for green skills development and environmental strategy formulation. The interview data did not provide any clue on the direct link between environmental collaboration and EI.

5.3.1.2.1 Collaborating Parties

Figure 5.2 encapsulates main parties that firms are collaborating/networking. The largest collaboration/networking is within the firm's groups, which are their subsidiaries, joint ventures, global partners and affiliates. The other collaboration is with associations, such as CICM[9], FMM[10] and IPIECA[11], and followed by government and suppliers. Lastly, one organization acknowledged that they work with NGO, which is Blue Earth.

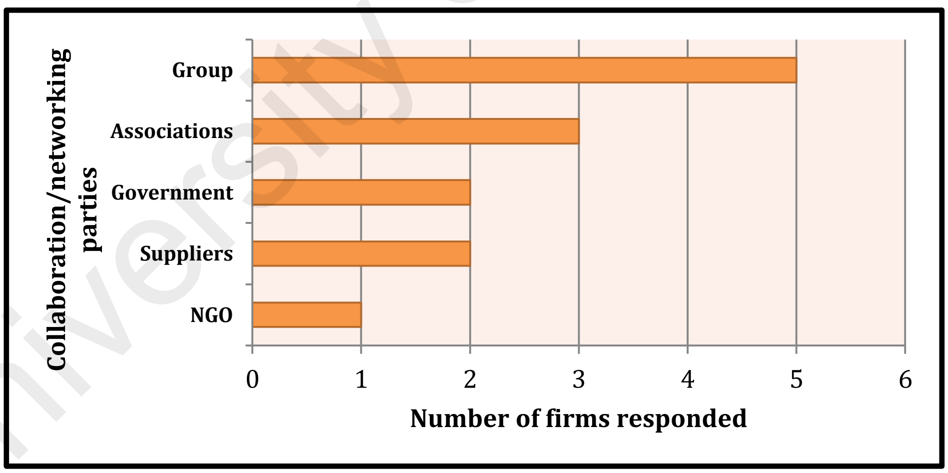

Figure 5.2 : Firms collaboration and networking parties
Note: Total number of firms interviewed = 6 (6 respondents). Data generated from the interviews.

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[9] Chemical Industries Council of Malaysia (CICM)
[10] Federation of Malaysian Manufacturers (FMM)
[11] The global oil and gas industry association for environmental and social issues (IPIECA)

5.3.1.3 Green Skills

In the context of achieving environmental agenda, firms have given a lot of attention in providing green skills to their employees. Creating awareness and providing trainings, have been the gateway for firms in providing green skills to their employees. Firms use the interaction of three mechanisms to create awareness and provide green skills to their employees, which are collective effort, self-realization, and continuous awareness.

Collective effort mechanism transpires when top management, department heads and employees are engaged together through several avenues such as workshops and environmental meetings. During this workshops and meetings, all three parties make decisions and conduct activities collectively. This mechanism strengthens the bonding and increases the trust among the member of the firm, which accelerates the firm's environmental commitment level. At the same time, environmental issues that require urgent attention enforcement is swiftly done through this collective mechanism.

Self-realization mechanism was used to instill the need for green skills and environment commitment voluntarily. Community engagement programs and problems based tasks were used to inculcate responsibility towards the society. Problem based task was used to place employees in actual situations where there are constrained by environmental issues and are required to search for solution to those problems. This mechanism automatically keeps the employees alert at all time.

Finally, constant information sharing via info TV (i.e., information sharing on television within the firms compound) and environmental programs especially 'Responsible care' campaigns was initiated under the continuous awareness mechanism.

"We create awareness mainly by sharing information and continuously updating the employees with the latest changes that are taking place. Our motto here is 'eco-together', so anything that we do in our organization is a collective effort." (Respondent A4)

"Under 'Responsible Care', promoting awareness is one of the important code. We believe that once employees understand their responsibility towards the environment then everything will automatically fall into place. Yearly, employees have to identify 12 problems in the plant that are hazardous and must write a report with solutions to those problems. We do this to educate and keep them alert." (Respondent A5)

"The learning and development department is responsible in organizing activities and programs to promote awareness. There are often awareness activities where we engage the staff with the society. It is more of a self-realization that caring for the environment is important for the society as a whole." (Respondent A2)

"Create awareness by sharing simple slides on info TV every day, which is part of 'Responsible Care' campaign." (Respondent A3)

Besides the three mechanisms mentioned above, firms use many training platforms to equip their employees with green skills. From the interview data, list of trainings that are provided to employees was grouped into seven categories (see Table 5.7). The top three forms of trainings popular among firms are: on the job trainings, environmental compliance trainings and environmental regulation workshops. Based on the top three training platforms it is evident that firms emphasized on trainings that enable them to comply with environmental regulations and standards.

Some firms have gone to greater lengths to provide green skills to employees. They have developed their own module, comprising structured assessment system to grade their employee's achievements. Furthermore, there are firms offering online training courses.

Table 5.7 : Types of trainings provided

Type of trainings	Number of firms resp0nded	Details	Conducted by
On the job trainings	√√√√√√	-Focus on areas where firms have comparative advantage	-Senior staff
Environmental compliance trainings	√√√√√	-Routinely conducted -ISO14001 & competency related trainings.	-External trainers -Senior staff
Environmental regulation workshops	√√√√√	-EQA 1972 -Updates on new regulations	-DOE officers -Senior staff
Engage with experts	√√√	-Sharing best environmental practices especially in the area of waste & chemical management	-External experts
Awareness trainings	√√√	-In-house or outside the firm (by associations) -Attending talks, seminars &conference	-Senior staff -External facilitators
Environmental courses	√√	-Own environmental syllabus -Exclusive training system -A structured assessment system	- Senior staff -External trainers
Online	√	-Online training system	-Self engagement

Note: Total number of firms interviewed = 6 (6 respondents). Data generated from the interviews.

5.3.1.3.1 Assessment of Employees Green Skills

To increase employee's participation and seriousness in obtaining green skills, an evaluation system is structured. Employees are assessed through causal learning, monitoring and fulfillment of key performance indicators (KPIs). At the same time, promotion and pay rise is linked to the evaluation system, as a motivation for employees to acquire those skills effectively.

> *"There is a promotion system in place, where at every stage there is trainings, exams and interviews. Environmental trainings are a substantial portion of the system and assessment. Employees need to work hard to get through all the stages." (Respondent A1)*

> *"There are certain KPIs that the employees need to achieve. There is causal learning to assess on how they do their work." (Respondent A2)*

"Employees are assessed through audit results and routine site visits." (Respondent A4)

"Employees are provided with a list of trainings that they need to attend. Fulfilling these training hours is part of their KPI, which will later be taken into consideration for pay rise and promotion." (Respondent A5)

Based on the skills and assessment system coined by the firms, it is evident that firms are committed towards sustainable manufacturing practices. However, the trainings implemented by the firms emphasizes on the compliance with the environmental regulations. There could be instances that the skills contribute to eco-innovations that assist firms to achieve minimum regulations requirements. Moreover, the interview results did not provide any lead showing strong linkages between green skills and EI. With reference to the earlier two determinants, environmental knowledge and collaboration clearly indicate that green skills are imperative to formulate firm's environmental strategies.

5.3.1.3.2 Challenge to Create Awareness

Creating environmental awareness and sustaining the awareness has been a challenge for some firms. Academic qualification/background hugely influences employee's acceptance and understanding towards the need to care for the environment. Respondents purported that generally employees with lower level of academic qualification exhibit lack of environmental commitment, which are mostly among the general assembly workers.

"There is different level of acceptance towards awareness. Employee's academic background determined the awareness that they are able to absorb. It is always challenging to spread the awareness among employees at the operational level." (Respondent A3)

"Academic qualification influences their level of awareness. Constant awareness is required to remind those with lower academic qualification."(Respondent A4)

5.3.1.3.3 Conceptualizing the Resource Model

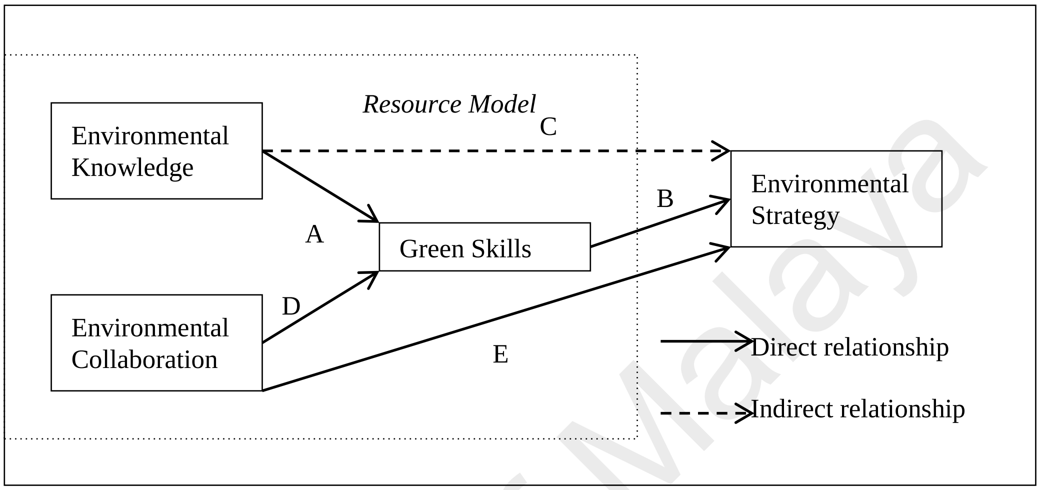

Figure 5.3 : Resource model

In accordance to information provided by the respondents, three drivers of EI: environmental knowledge, environmental collaboration and green skills did not indicate strong direct relationship with EI. Figure 5.3 exhibits the resource model for chemical manufacturing firms in Malaysia. Environmental knowledge and collaboration assist in developing firm's green skills capability (Link A & D). Employees equipped with green skills and positive behavior towards protecting the environment churn ideas to develop firm's environmental strategy (Link B).

Furthermore, environmental collaboration revealed the ability to influence firm's environmental strategy (Link E). In contrast, environmental knowledge exhibits the capability to indirectly influence environmental strategy through green skills (Link C). Thus, it is evident that these three drivers are strong technology push factor that upgraded employee's general skills to green skills. These skills guide firm's environmental strategy (i.e., material usage and technical aspects for sustainable manufacturing).

5.3.2 The Strategy Model (Model 2)

This section brings forward the discussion on how two technology-push (i.e., environmental collaboration and green skills) and demand-pull factors (i.e., market pressure and export behavior) mechanize a chain effect that contributes to the formulation of environmental strategy and directs firms EI initiatives. The influence of these factors on the organizational culture, and the dynamics of firms to withstand the challenging environmental issues are also elaborated in this section.

5.3.2.1 Market Pressure

The responses from the interview firmly indicated that firms responded to pressure from consumers and competitors. However, from both these pressure, consumer pressure was given greater consideration. Respondents indicated that increasing environmental awareness, since the last two or three decades, have globally promoted green consumerism. The responses further indicated that environmental awareness among Malaysian consumer might not be obvious but change has actually taken place and educated consumers are making smart choices these days. Malaysian consumers' environmental awareness will eventually be on par with those from the developed countries. As a result, demand for environmentally friendly products are increasing in Malaysia at a slow pace.

In response to budding consumer pressure, firms have incorporated strategies to respond to their green consumers' needs; and started to strategies themselves to handle stiff consumer pressure in the future. Informants acknowledged that when there is consumer pressure, firms frequently place greater attention to the product. Product reengineering/redesigning is the common strategy employed to address this pressure. From the analysis, it is clear that the current rate of pressure that firms are facing is largely international.

> *"Consumer pressure internationally has been there for a long time now. In the case of Malaysia we cannot ignore the fact that educated consumer are looking for green products. We project that in the near future, Malaysian consumers will demand for green products, similar to western countries. When it comes to consumer pressure, it is the product that receives greater attention by us and reengineering is the way out." (Respondent A2)*

> *"Consumers/clients demand for environmentally friendly products. This is the trend lately. Understanding consumer needs and acting accordingly is one of our organization mission. There is a carefully designed action plan to tackle this problem." (Respondent A6)*

> *"Nowadays consumers are smart, they care for the environment. They require products that are safe for them and the environment…product redesigning is the solution to this pressure" (Respondent A4)*

Next is pressure from the competitors. From the response, it was visible that large firms are on par with their competitors. These large firms have created their own niche market and some of them are dominant market players. It was noticeable that they do benchmark themselves with the main market players, and with those who have obtained a certain level of recognition in their participation and contribute in promoting sound environmental practices globally. The pressure from competitors was not proven as intense as the pressure from the consumers.

> *"Benchmarking is done with international companies, mainly with our global competitors who have been in the market for many years."(Respondent A1)*

"We have created our own brand and niche. We do monitor competitors but we are always ahead of them…it is our philosophy 'striving for the best'." (Respondent A2)

"Many firms are going green nowadays and there is tough competition out there, so anyone who intends to remain competitive has to strategize." (Respondent A3)

In response to which pressure is greater for them to eco-innovate, market or non-market, all the respondents agreed that market pressure was more influential. Since, there is societal awareness in Malaysia; it is still not strong to the extent that local NGOs and pressure groups are able to pressure the firms. If there is any non-market pressure that firms respond to, it is the regulatory pressure.

Firms have come into terms that to remain competitive, they have to respond to their customers' needs rather that following what their competitors are doing. The reason could be that customers in different regions are composed with different level of awareness. Firms are serving diverse segment of customs from different regions. Thus, following their competitors might not seem to be a suitable strategy. Action plans to respond to their customers' needs seems to be more practical. Finally, there was no indication of a direct relationship between the market pressure and EI. Market pressure had commanding influence on the strategy that firms embark to provide environment friendly products. Therefore, it was found that firm's market pressure influenced EI indirectly through environmental strategy.

5.3.2.2 Export Behavior

Foreign regulatory settings have a direct and commanding influence in the creation/adoption of EI. This is because, when informants were asked on the need to comply with certain environmental requirements on their exports, their instant feedbacks were "*Yes*", "*Certainly*", "*Of course*", '*We have to*" and "*Definitely*". These responses show obligatory compliance to foreign environmental requirements. A few informants even regarded the requirements as "*Very strict*". Firms have varying strategies in response to their export orientations. Some firms had comprehensive strategy, which enables them to address all their importers environmental requirements. Meanwhile, those addressing specific needs used multiple strategy approach to solve this issue.

> *"Responsible Care Management System (RCMS) is a holistic system that manages and solves major environmental related issues. The deployment of this system automatically enables us to meet all the requirements set by the foreign firms." (Respondent A5)*

> *"Different countries have different requirements, it is like their own version of REACH, so different strategies are used to comply with their standards." (Respondent A1)*

Table 5.8 contains the list of standard set by foreign countries for compliance by the local firms. The ISO14001 is the main and the minimum requirement that each exporting countries need to meet. Then, followed by REACH and EHS, which are specific standards designed for chemical related manufacturing. Finally, ISO/TS 16949 and RSPO, these are more product specific requirement imposed only on firms that are producing such products. Firms' active actions in meeting these requirements are seen to potentially influence the formulation of their environmental strategy. With varying strategies employed by firms to meet their importers environmental requirements, it is a clear that firms export behavior influences their environmental strategy, which later drives their behavior to eco-innovate.

Table 5.8 : Foreign firms environmental standards requirements

Regulation/ requirements	Number of firms responded
ISO 14001[12]	√√√√
REACH[13]	√√√
EHS[14]	√√√
RoHS[15]	√√
ISO/TS 16949[16]	√
RSPO[17]	√

Note: Total number of firms interviewed = 6 (6 respondents). Data generated from the interviews.

5.3.2.3 Environmental Strategy

In the process of synthesizing and understanding the inter play between the determinants of EI, the most striking finding is that there is no perfect direct link between the majority of the determinants and EI. The findings revealed that the determinants are more critical for the development of firm's environmental strategies. Based on the interview, informants often link the EI determinants to a stream of activity that promoted the EI. Terms frequently used in reference to this activity were plans, strategies, goals, actions and initiatives. Even though the terms were different but from their responses, it was apparent that they were refereeing to the same context which is environmental strategies.

The EI determinants altered organizational culture and provided the dynamics under which environmental strategies are developed. Organizational culture is referred as 'a

[12] ISO 14001 is no longer alien to the environment community and it has become common or a mandatory requirement for all exporting firms to have the certification.
[13] Registration, Evaluation, Authorization & restriction of Chemicals (REACH) is a list of criteria formulated by European union to protect the ecosystem from threats posed by chemicals and to promote innovation and competitiveness in the chemical industry.
[14] Environment, Health and Safety (EHS) requirements are the ones set under OSHA.
[15] Restriction of Hazardous Substances (RoHS), which are requirements developed by EU to regulate the use of toxic substances in products.
[16] ISO/TS 16949 is a quality management system that looks into chemical substances that are used in the manufacturing of automotive related products, for example, polymer that is used in the manufacturing of car cushions/seats.
[17] Roundtable Sustainable Palm Oil (RSPO) is a non-profit organization. RSPO has formulated social and environmental requirements that firms need to comply in order to produce Certified Sustainable Palm Oil (CSPO). RSPO has an integrated mechanism that looks into the total palm oil supply chain.

pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid, and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems' (Schein, 2004). With reference to dynamic capability theory, dynamics are the agility and ability of the firm to rapidly respond to the continuous change and progress occurring in the firms.

The interview data affirms that firm's organizational culture is infused with new assumptions that have changed the nomenclature of managing organizational issues. Firm's initiative in providing solutions to green consumerism and other forms of environmental pressure indicates that they have adopted new beliefs and values. Environmental commitment and realization on the importance of long-term sustainability portrayed by firms, further confirms the change in organizational culture. Firm's dynamism was reflected as they responded to emerging environmental issue. They developed capabilities to absorb new environmental knowledge through collaborations and upgraded their green skills using better information channels. These capabilities enabled them to reduce waste generation and increase energy efficiency.

Therefore, EI determinants namely environmental knowledge, environmental collaboration, green skills, market pressure and export behavior was found to strongly influence environmental strategy. The interview data demonstrated that these determinants are fused with the changes in organizational culture and firm dynamism to formulate strategies to solve environmental problems. Mechanics that shaped firms environmental strategies are presented in section 5.3.4.

5.3.2.4 Conceptualizing the Strategy Model

Market pressure and export behavior provided the firms with the information on transitions that is taking place in their product market. Meanwhile, environmental collaboration and green skills equipped the firms with global environmental knowledge and technical 'know how' that is required to respond to the transitions. One stream of significant activity emerging from these determinants is changes in the organizational culture and resistance in firm dynamics to tackle demanding environmental issues.

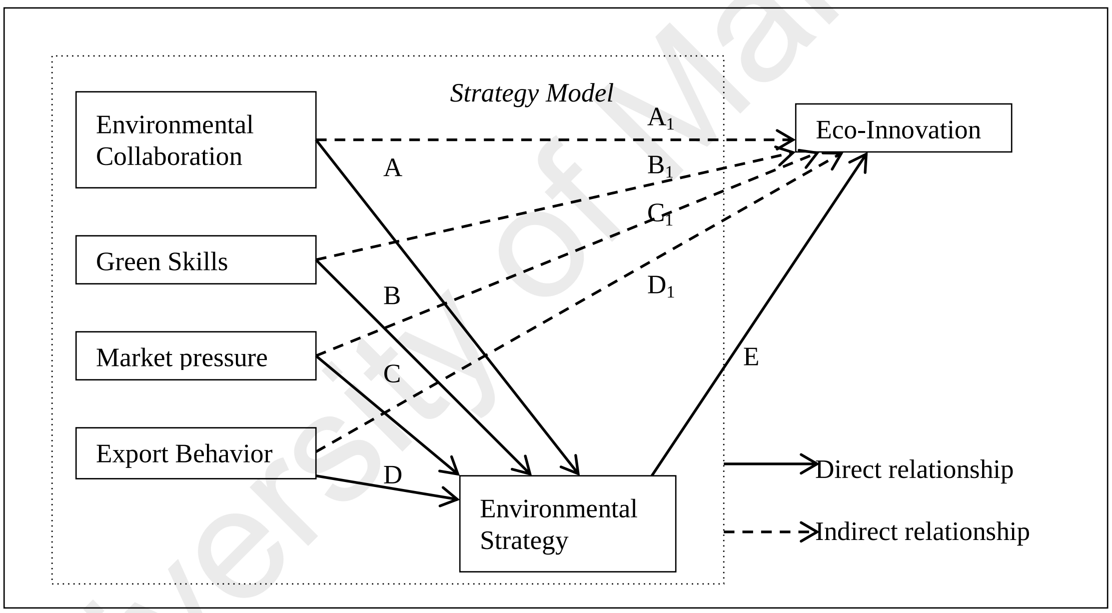

Figure 5.4 : Strategy Model

The interference between the determinants and shift in organizational culture leads to the development of environmental strategies, represented by the direct link in Figure 5.4 (Link A, B, C and D). Later, these strategies influence the EI (Link E). However, besides the direct link, an indirect link was also apparent where the four determinants influence EI through environmental strategy (Link A_1, B_1, C_1 and D_1).

5.3.3 The Eco-Innovation Model (Model 3)

Environmental regulation was found to be a delicate determinant to be explored. Each firm has different perspective towards the environmental regulation. Their response towards environmental regulation is always based on the preference of these regulations. This section sheds some light on these issues and explores how environmental regulation and firm's financial resources influence EI.

5.3.3.1 Financial Resources

The firms indicated that there is an allocation for environmental R&D. The R&D activities are financed internally and no external funding involved. Based on the responses, it was evident that firms are not financially constrained. However, when asked the percentage of allocation for environmental R&D, they were unable to provide an accurate figure. This is because the environmental R&D expenditure is aggregated together with other forms of environmental compliance expenditure. The expenditure was roughly estimated that for environmental purposes the allocation is one to two percent, and a large portion is devoted to product related R&D.

> *"It is around 1% and mostly product related R&D." (Respondent A3)*

> *"Around 1% to 2%...R&D labs focus on product research, especially improving the product life cycle." (Respondent A4)*

5.3.3.1.1 Barriers to Environmental R&D

Respondents highlighted that there are several barriers encountered by firms to environmental R&D. The major barrier was convincing the top management to approve the R&D budget. A detailed and credible financial presentation of the R&D projects is required to obtain the approval form the top management. The aspect that needs further detailing is the return on investment. The external benefits that accrue from these projects need to be presented in terms of dollar and cents.

> *"For new projects the problem is always getting people's perception, on the importance of the project. Selling the projects to the top management and getting their approval can be tough." (Respondent A5)*

> *"Setting the priorities and convincing the top management can be difficult. Cost benefits analysis need to be properly done to convince them as we are competing for the funds between various projects." (Respondent A1)*

Besides convincing the top management on the importance of this R&D projects, outdated R&D technology is also a barrier especially for old firms. A change of the facilities/technologies entirely imposes a high cost. Another barrier that firms are dealing with is customer's rejection of the new product. Green products are evolving extremely fast. Firms need to consider the relevance of the current R&D outcomes in the future.

> *"We have been in the industry for many years and our R&D facilities were built since then. Upgrading has been done but it is not sufficient. Changing this machines and equipment's entirely is going to be very costly" (Respondent A6)*

> *"The new products are sometimes rejected by customers. We need to be mindful on the type of R&D that we do." (Respondent A4)*

Other constrains highlighted during the interview are cost and time related to R&D. However, these barriers seem to impose the least constrained firms to expedite their R&D projects. Since, large firms are not financially constrained, they have established R&D capacities, consists of sophisticated labs and skilled researchers.

> *"Large organizations are not financial constrained. They are capable of doing extensive R&D"(Respondent A3)*

> *"We have so many engineers working on environmental R&D, I think we are the biggest." (Respondent A1)*

5.3.3.2 Environmental Regulation

When respondents were asked about aspects related to environmental regulations, majority of the respondents expressed their satisfaction with the enforcement of the new system. The new system was regarded user friendly and provided firms ample of room for firms to incorporate their own ideas in order to improve their environmental performance. This is because the new system comes with a built-in self-compliance mechanism, where DOE outlines the bigger scope of pollution mitigation plan and the firms are given the liberty to determine the specific elements related to the bigger scope. Respondents referred to the new system as better and effective because they understand their production process and organization structure better. Thus, the new system allows them to fit their own unique features into the pollution mitigation plan.

> *"Compared to 10 years ago we are better. DOE has a new system, where they want the firms to be more independent. They give us the broad scope and we fill in the detail scope according to our own production mechanics and organization system." (Respondent A1)*

"Their mechanism has changed over the years. Now is more on self-compliance. The change that they have done is good and effective to a certain extent." (Respondent A3)

According to the responses provided by the firms, it was evident that large firms did not encounter any problems from the regulators. This is because they complied with all the pollution mitigation requirements and submitted their environmental reports on time. Furthermore, if there were any emerging environmental issues in the plant and required serious attention, DOE was immediately informed. Taking into consideration the proactive behavior portrayed by the firms, DOE has developed a certain level of trust and faith towards large firms. Thus, not frequently monitoring them and ready for negotiation if any unexpected issues takes place.

"DOE have faith in large organizations like us. We immediately report to them if there are any issues. We submit all our reports to them on time." (Respondent A2)

"The regulators are informed about any changes that take place. Because we are sincere to them, they understand us and an effective negotiation frequently transpires between us. So far DOE is efficient and competent." (Respondent A4)

"The enforcement of environmental regulation has improved with the new system. As there are new chemical regulations it will take time for them to develop the capability to improve the system further." (Respondent A5)

From the above discussion, there is strong basis that environmental regulations do influence eco-innovation. Initiatives taken by firms to comply with environmental regulations set by DOE leads to eco-innovation. When asked whether is there any environmental innovation predominantly because of existing environmental regulation, four out of the six firms that were interviewed acknowledged, that environmental regulation considerably influence eco-innovation. The exact extent of the effect on eco-innovation is unclear.

Some respondents stated that they are doing a lot more to protect the environment as compared what is required by the environmental regulation; and the regulation do not impose a significant impact of their eco-innovation initiatives. However, the findings affirm that environmental regulation definitely provides the initial force to eco-innovate. The continuous assessment carried out by regulators through reporting and monitoring provide positive outcome for the eco-innovation initiatives among firms. A direct relationship between environmental regulation and eco-innovation was observed

> *Regulation has no great impact on us. RCMS that we have require us to comply more as compared to what DOE require, so we are ahead." (Respondent A5)*

> *"We are doing a lot more."(Respondent A1)*

Among the environmental regulation regimes, command and control regulation has been the force behind the eco-innovation. Respondents indicated that environmental standards under the command and control regime were mainly influential. Based on the interview findings, for the Malaysian command and control regulation, it is necessary to stimulate the basic types of EI, which enables the firms to meet minimum pollution abatement requirements set by the authorities.

> *"In the case of Malaysia we need command and control regulation to influence environmental innovation."(Respondent A5)*

> *"Command and control is important especially for basic environmental innovation to meet at least the minimum mitigation requirements." (Respondent A1)*

Despite their satisfaction with the new system, respondents did express their dissatisfaction. There is no consistency in the enforcement of system. The element of flexibility and negotiation embedded in the new system contribute to different enforcement treatment across firms. The enforcement is different from one organization to the other, which is regarded as unfair.

> *"Messy enforcement, the enforcement differs from one company to another." (Respondent A6)*

> *"They are flexible and open for negotiations when dealing with issues that they have to be strict. And during situations where they have to allow flexibility and negotiations they are strict…it is unfair at times." (Respondent A4)*

5.3.3.3 Regulation Stringency

Discussion in the prior section indicated that the enforcement of environmental regulations in Malaysia has increased. The command and control regulations that influenced the EIs have transpired. This information provides positive platform to suggest that environmental regulation stringency has increased over the years. However, when respondents were questioned on the stringency of the environmental regulation, they gave a very standard answer which is "it depends". Denoting that certain aspect of the environmental regulation is stringent, and certain are not.

There are a few factors behind this situation. First, the penalties that are being imposed are low and need to be revised. Second, the regulation is outdated and considered more lax compared to other countries. Third, stems from the regulators themselves. DOE officers were regarded as inexperienced. The newly appointed officers are young and still in the learning process. Thus, their action and interpretation of the regulation is not consistent.

The authorities keep changing the person is in-charge of the regulation and handling of a particular firm, which further complicates the situations. These factors diluted the stringency of the environmental regulation.

> *"There are some areas that we are stringent and some areas need to be given more attention." (Respondent A1)*

> *"It is stringent but certain aspects only…penalties need to be revised" (Respondent A4)*

> *"Malaysia's chemical regulation is old and outdated compared to other countries. DOE officers have lack of experience as most of them are in the learning process." (Respondent A5)*

> *"DOE officer's lack of knowledge and experience. Their action and interpretation are both different." (Respondents A2)*

> *"The officers are young and inexperience and the person in charge of the regulation keep changing." (Respondent A6)*

Respondent shared their experience and knowledge dealing with foreign environmental regulation. Figure 5.5 provides the list of countries that have lax and stringent environmental regulation as compared to Malaysia. In comparison to Malaysia, the environmental regulation of the ASEAN countries is more lax, except for Singapore and South Korea. Malaysia was claimed to be doing a lot better to protect the environment as compared to their ASEAN counterparts in the area of waste management and air pollution. However, in comparison to EUROPE and Australia Malaysian environmental regulation is lax.

> *"In Southeast, Malaysia is better than others when it comes to the enforcement of environmental regulation in manufacturing industry. But when compared to EU, Japan and Australia we are not that stringent" (Respondent A6)*

"In the ASEAN region we are better, as specially in the area of waste management and air pollution." (Respondent A5)

"We benchmark EU and Australia when it comes to environmental standards." (Respondent A1)

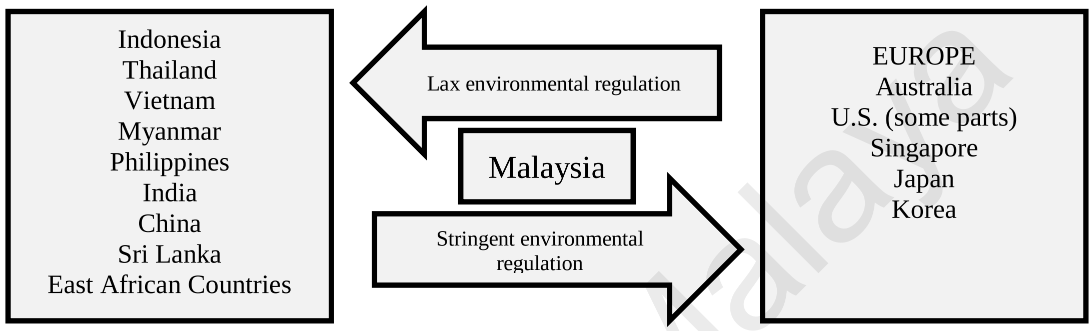

Figure 5.5 : Foreign countries with stringent and lax environmental regulation as compared to Malaysia.

It was a challenging task to gauge the environmental regulation stringency. The stringency of environmental regulation has increased over the years. However, based on the responses, the level of stringency is not up to the level that it forces firms to eco-innovate. Issues like low penalties and inexperienced regulators could reduce the level of stringency. Concisely, stringency was not seen as significant factor that influence EI, but a weak direct relationship between eco-innovation was observed.

5.3.3.4 Conceptualizing the Eco-Innovation Model

The EI model is an extension of the strategy model. Financial resources, environmental regulation and regulation stringency are the additional determinants included in the model. These three determinants display a direct relationship with EI (Link F, G and H). Among the three drivers, environmental regulation proved to be a strong determinant of EI. Since, firms are proactively complying with all the regulations set by the authorities, largely this compliance has led to EI.

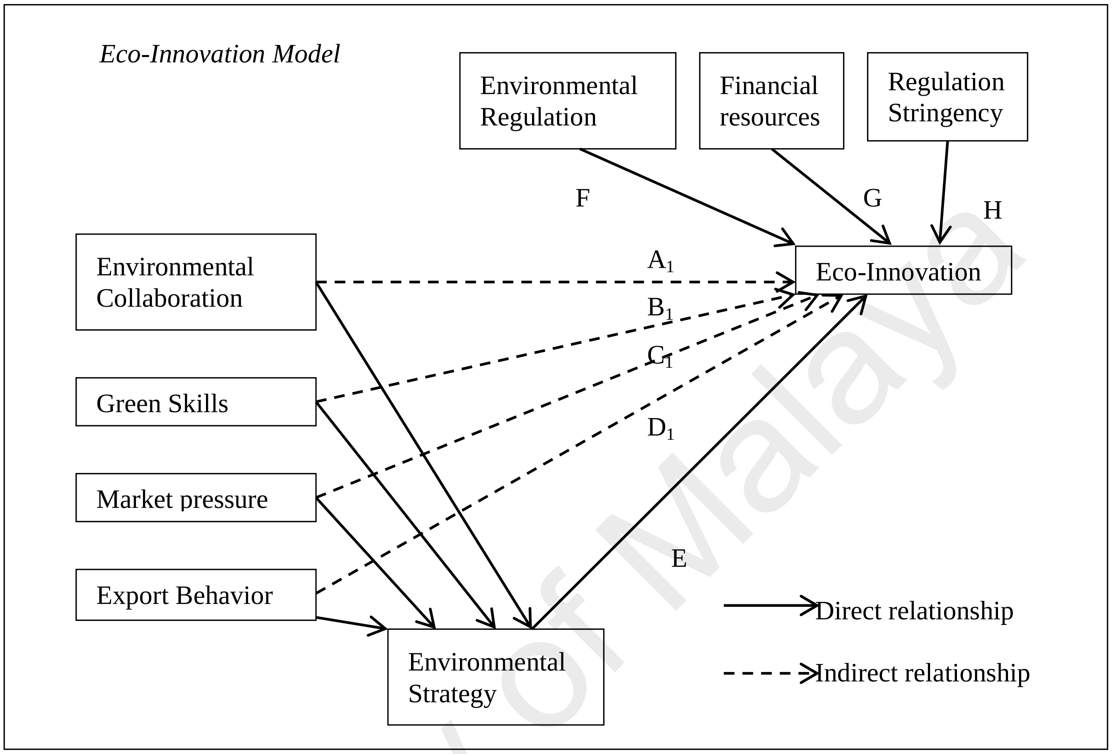

Figure 5.6 : Eco-Innovation model

For financial resources and regulation stringency, besides showing direct relationship, prove to be weak determinants of EI. Large firms are not financially constrained and decisions to eco-innovate are not largely influenced by their financial endowments. On the other hand, regulation stringency has increased over the years but does not seem to be sufficient to stimulate expected level of EI to mitigate pollution. Finally, environmental collaboration, green skills, market pressure and export behavior exhibit an indirect relationship with eco-innovation through environmental strategy.

5.3.4 Mechanics Behind Environmental Strategy (MBES)

From the interviews, environmental strategies play a crucial role in bringing together firm resources and capabilities for eco-innovations. The rapidly increasing and complex environmental issues have challenged these firms to formulate superior environmental strategies to sustain their competitive advantage (Chen, Ong, &Hsu, 2016; Journeault, De Ronge, & Henri 2016). For firms especially in developing countries, this process gets even tougher as they need to invigorate their existing capabilities while integrating new ones to handle unfamiliar and demanding actions. Considerable efforts are placed by the firms in order strengthen capabilities that are able to effectively shape their environmental strategy. We found through our interviews that there are certain important mechanics that are involved to translate firms' environmental concerns and issues into environmental strategies. These mechanics are referred as mechanics behind environmental strategy (MBES), which are the forces involved in the formulation, design and implementation of environmental strategies[18]. Through the interviews, this strategy involves seven important mechanics.

From a literature search, it was found that Mårtensson & Westerberg (2014) and Epstein & Roy (2007) have explored some of the requirements of effective environmental strategies which strongly related to the MBES that was found in this study. Mårtensson & Westerberg (2014) explored five vital requirements to design an effective environmental strategy. This includes building employee skills and experience, strengthening the relationships between internal and external stakeholders, enhancing communication channels, promoting cooperation and control and finally, restructuring the firm's material flow. Epstein & Roy

[18] In this study, the concept of MBES was coined by reviewing meager amounts of studies in this area (Epstein & Roy, 2007; Mårtensson & Westerberg, 2014).

(2007), on the other hand, investigated the coordination and control within multinationals on the facet of environmental strategies. Their findings indicated that the headquarters exert greater control over issues pertaining to setting environmental standards, initiatives and strategies evaluation as opposed to business units to ensure consistency.

In this regard, MBES itself can be considered as one of the dynamic capabilities of the firms whereby the accomplishment of enterprises is through the convergence of heterogeneous resources endowed to them and their unique capabilities, which can serve as the foundation for the mechanics behind the environmental strategies. Additionally, the concept of complementary assets (Teece, 1986) serves as an important substance in this study. Complementary assets refer to the capabilities and infrastructure that support an innovation to be successful. From the environmental strategies viewpoint, the notion of complementary assets refers to the assets needed to gain competitive advantage with the implementation of environmental strategies (Christmann, 2000). Therefore, a successful MBES that constructs an award-winning strategy is definitely a valuable asset to raise the competitive advantage of a firm.

In this section, seven mechanics of the environmental strategy that emerged during the interviews are presented. The seven mechanics consists of central system, internal system, specific environmental management unit, quantifiable measurement, strategy alignment, collaboration and collective involvement. These mechanics are grouped into two categories based on their nature of behavior. Finally, the discussion on the importance of top management commitment to integrate these seven mechanics is explained.

5.3.4.1 Central System

All the respondents stated that a central system at the headquarters formulates the primary environmental strategies of the entire organization. This system consists of a selective group/team from the headquarters, which is purposely assigned to manage the primary strategy formulation process, by taking into consideration the organization's environmental vision and mission. The headquarters additionally, have determined a specific set of guidelines/framework[19] to administer the entire formulation of the process strategy. Finally, the actions of the business units are based on these primary environmental strategies. This is clearly stated by some respondents:

> *"Global team formulates the strategies. We have a 'control framework', which are guidelines for us to follow. Everything is specified in the guidelines, so this makes the process much easier and structured." (Respondent A2)*

> *"Environment team formulates the strategies. For every environmental issue, there is a group in charge of it." (Respondent A1)*

Given the fact that the chemical industry is a highly risky and polluting industry, the headquarters seem to obtain certain control in the formulation of the environmental strategies. These centralized mechanics safeguard the firm's corporate image as claimed by scholars (Walley & Whitehead, 1994) and control the complexity to be dealt with as they operate at multiple locations (Baligh, Burton, & Obel, 1996).

[19] The headquarters have developed a standard guideline/framework that provides a detailed set of instructions and procedures, which is mandatory for every department, unit or employee to follow during the course of environmental strategy formulation. These guidelines/frameworks encapsulate several important aspects such as budgeting, resource usage, chain of command, safety standards, performance standards and others.

5.3.4.2 Internal System

Besides the central system, the interview results revealed that there is an internal system within the firms. The purpose of the internal system is to localize the primary environmental strategy in response to local regulatory needs and firm's capabilities. In addition, under the internal system, the top management identifies firm level environmental issues through feedbacks from every department. These issues are addressed through more firm specific environmental strategies, which are formulated using similar guidelines/framework set by the headquarters. These strategies tend to be short term in nature compared to the primary strategies.

Interestingly, in most cases, the firm level strategies are executed through environmental projects, which are collaboratively planned by the top management and the respective divisions. These projects take into consideration the current organizational and regulatory needs as well, while staying intact with the firm's environmental vision and mission. In this aspect, proximity is also important, as some of the environmental issues are location-based. Therefore, the projects are designed to address the current environmental issues faced by the firms and to fulfill the regulatory requirements.

> *"We have both long-term and short-term strategies. The managing director formulates the short-term strategies and looks into the practical side of the strategies. These strategies take into account the local organizational and regulatory needs." (Respondent A4)*

> *"At the local level, the environment department with the consultation of top management formulates the strategies that are in accordance to the organization's vision and mission." (Respondent A5)*

> *"Based on the 'Control Framework' provided by the headquarters, we set our projects and these projects involve other divisions as well. These projects are planned to achieve the group's main objectives." (Respondent A2)*

Formalization was observed within the internal system, where the formulation of firm level strategies is based upon a set of guidelines/framework provided by the group/headquarters. It was evident that the final decisions on environmental initiatives were decided by top management decisions and guidelines by group/ or the headquarters. The findings of this study validate past evidences that the formalization process is an important aspect within the internal system. For corporate greening to advance, formalization is necessary (Takahashi & Nakamura, 2005). It reduces headquarters' involvement (Roth, Schweiger, & Morrison, 1991) and gives a little autonomy to the firms to incorporate ideas into strategies (Hales, 1999), thus allowing firms to leverage on it and earn competitive advantage.

5.3.4.3 Specific Environmental Management Unit

Decision-making regarding environmental strategies involves various divisions and personnel within the organization (Torre-Ruiz *et al*., 2015). Thus, coordination is of paramount importance. Indeed, communication is crucial (Mårtensson & Westerberg, 2014) to streamline the entire system. Addressing solutions to coordination and communication issues, every informant acknowledged that there is a requirement for specific environmental management unit to oversee all environmental-related issues. This unit is responsible for synchronizing feedbacks between top management and the departments, and various divisions. In addition, this unit also initiates and facilitates as well as monitors the approved environmental projects. Lastly, this unit is also deemed as a one-stop resource center for everyone to obtain environmental-related information.

> *"Global Environment (GE) team takes charge of all environmental issues. There are many units under GE and each unit is designated to manage a specific environmental issue." (Respondent A1)*

> *"HSED monitors all the green strategies and projects. They will coordinate the top management and the departments." (Respondent A4)*

> *"HSED initiates and facilitates environmental projects. HSED is basically the one stop center to get all the information." (Respondent A3)*

From the responses, it was evident that this unit is multifunctional. This study believes that a proper organizational structure and environmental resources within this unit may speed up the implementation process of the strategies. The setting of a specific environmental management unit, therefore, reflects a high level of importance that the top management gives towards environmental issues (Del Brío, Fernández, Junquera, & José Vázquez, 2001).

5.3.4.4 Quantifiable measurement

The interviews, on the other hand, also disclosed that the majority of the firms use quantifiable measurements to gauge the success of the environmental strategies. Apparently, this quantifiable measure itself is a detailed and planned document to ensure consistency. Electricity cost reduction, energy intensity index, carbon reporting and percentage of waste reduction, for example, is some of the main targets in their environmental key performance indicators that are frequently assessed. However, some respondents acknowledged that as a measure of their strategy's success, they must at least meet environmental requirements set by the Department of Environment, Malaysia (DOE). Firms raise the expectation bar higher upon achieving current targets to further reduce their carbon footprints. In other words, all the firms undertook continuous improvement.

> *"There are key performance indicators (KPIs) for every environmental initiative. The KPIs itself is a huge document; we call it the 'A1 Technical Standard'…goals that we set are frequently measured. For example, operation level goals are measured quarterly." (Respondent A1)*

> *"Annually, reviewing our environmental projects, setting energy intensity index and at the least, meeting the requirements set by DOE. In our organization, we are always raising the bar to be better." (Respondent A2)*

> *"There are targets, which are time bound…reduce the electricity bill by 1% every year. SMART system is also used…there is tough competition out there...everyone is going green." (Respondent A3)*

The firms' initiative to review frequently their environmental actions and targets provide an avenue for improvement. The assessment of their strategies enabled them to raise the bar higher once targets are achieved, especially in the context to be recognized as the most environmentally friendly enterprise among their competitors. Therefore, firms believe that a proper evaluation system warrants the success of their environmental strategies (Ilinitch *et al*., 1999; Lober, 1996).

5.3.4.5 Strategy Alignment

Strategy alignment is another mechanics of the environmental strategy. Firms often aim for desiring cutting-edge and innovative solutions to their environmental problems. In addition, firms seek to obtain advanced green knowledge, to stay ahead of their competitors, who are enthusiastically involved in the green transformation. Therefore, firms revise and review their strategies within a period of three to five years to align strategies with globally emerging environmental issues.

> *"There are absolute goals and relative goals, which are revised periodically…always looking for new innovative solutions to solve environmental problems. Even currently, we are not satisfied with what we are doing." (Respondent A1)*

> *"We have a 5-year environmental improvement plan. This plan is constantly viewed so that we keep abreast with the changes that are taking place…it's a competitive world out there." (Respondent A2)*

> *"Our targets are revised every three years…market study is conducted to introduce new plans." (Respondent A6)*

5.3.4.6 Collaboration

Collaboration between top management, department and employees is the backbone of environmental strategy formulation and design, based on indicators provided by respondents. To understand this collaboration, it is important to observe the path that firms use to structure their internal strategies.

A common practice among firms is to request their staff to state the environmental-related problems in their departments followed by solutions to those problems. Their environmental management unit then uses this information to structure environmental projects and propose them to the top management. The selection of the ideas and solutions is based on the cost-benefit analysis. Usually, the chosen solutions to solve environmental problems should justify the investments and the benefits the firms obtain. Once approved, the ownership of these projects is handed over to the departments, and the success of these projects is the responsibility of the departments. These projects, therefore, are the firm's environmental activities under their internal strategies.

> *"HSED will go around asking every department on the problems that they face…list down the problems and the proposed solutions. These proposed solutions are then converted into projects…HSED writes a proposal to the top management to approve the projects." (Respondent A3)*

> *"Every year, we have a project turnaround…to identify projects…involves other divisions as well. Then we propose to the management for approval and budget. Once approved, the departments will take charge of the projects." (Respondent A2)*

> *"Everyone is involved in the strategy making…over here, every individual is responsible in protecting the environment…eco-together."(Respondent A4)*

After examining the responses from all the firms, this study inferred that every individual in the firm plays a significant role in planning the environmental strategies. The intensity of the collaboration as seen by these firms has the possibility to increase the success rate of their environmental initiatives, since encouraging the participation of organizational members in strategy development automatically place them in a learning process and creative process (Cacciolatti & Lee, 2016). As a result, these processes can help them to achieve organizational, environmental goals, technical skills and knowledge required to mitigate pollution (Mårtensson & Westerberg, 2014).

Figure 5.7 presents the main departments that firms consider during their strategy formulation process. Mainly, six key departments are involved in the strategy formulation process. The most important is the production and operation department followed by the maintenance, technology and emission reduction department with similar levels of involvement. The finance department is shown as the last key department to be involved.

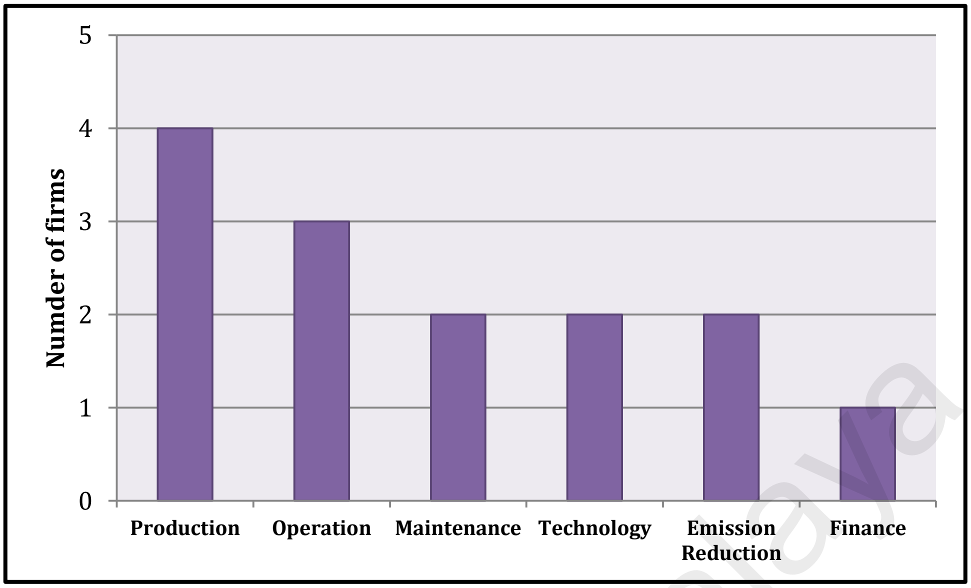

Figure 5.7 : Departments that are primarily involved in environmental strategy formulation
Note: Total number of firms interviewed = 6 (6 respondents). Each firm indicated more than one department. Data generated from the interviews.

5.3.4.7 Collective Involvement

While collaborative effort is involved during the formulation and designing of environmental strategies, collective involvement among employees however, is found in the implementation of these policies. For most of the firms, the involvement was voluntary, because caring for the environment has become a part of their corporate culture. However, a few firms also used guidelines, directives and campaigns to encourage their employees' participation.

> *"Every staff is involved…top to bottom and left to right, we even involve our contractors. Over here, we manage their entire supply chain. It is 'eco-together'." (Respondent A4)*

> *"Everyone in the organization is involved in the implementation. Taking care of the environment is basically a culture here." (Respondent A2)*

"There is a detailed policy guideline, which requires everyone in the organization to be involved." (Respondent A1)

Two informants reported that directive measures were used to mainly increase the participation of employees at the bottom level. Their lower level of education hindered them from grasping environmental awareness, which later transpires into a poor level of involvement.

"The bottom level follows procedures and instructions set by the safety committee. It is difficult to get full commitment from the bottom level, maybe due to their educational level." (Respondent A6)

"Employees at the operation level have a lower level of education and they always show lack of interest and awareness." (Respondents A3)

The use of voluntarism and directives mainly involves a different level of employment status. The most important seems to be creating environmental awareness and incorporating that awareness as part of the corporate culture.

5.3.4.8 Categorizing the Mechanics and Top Management Commitment

Observation provided some basis to divide the mechanics into two categories: system and commitment. System is a well-structured and guided system that governs the transformation of environmental objectives into initiatives that the firms follow. Effective environmental strategies, moreover, depend on a robust system and structure (Christmann, 2000; Epstein & Roy, 2007). Five mechanics that qualified in the system category are central system, internal system, specific environmental management unit, quantifiable measurement and strategy alignment (see Figure 5.8). From the findings, also it is noted that over the years, firms have been investing in relationship-building among the members of the organization (Mårtensson & Westerberg, 2014) to increase their commitment. Hence, the second category is known as commitment, which consists of collaboration and collective involvement. Systems and commitment are the two most important mechanics behind the environmental strategy.

One significant finding from the interview, which needs utmost attention is that, the governing of the MBES requires the top management's commitment. If the environmental management unit is unable to obtain the commitment of the top management, its entire environmental strategy implementation will be impossible. It is the top management's commitment that serves as the key driving force of the MBES. Due to the pressure from the group/headquarters (Boiral *et al*., 2012), strong and influential top management commitment (Banerjee et al., 2003) were seen present in the organization that was interviewed. The top management has put in a lot of effort and commitment in organizing the MBES into a formal structure.

The top management has invested important strength in promoting active interaction within the organization, which potentially builds trust and enhances commitment (Ring & Van de Ven, 1994) among organizational members. The returns on this investment have been rewarding, such as the development of a collaborative mechanism in planning the environmental strategies, and provision of a dynamic on-the-job learning experience for employees on environmental issues.

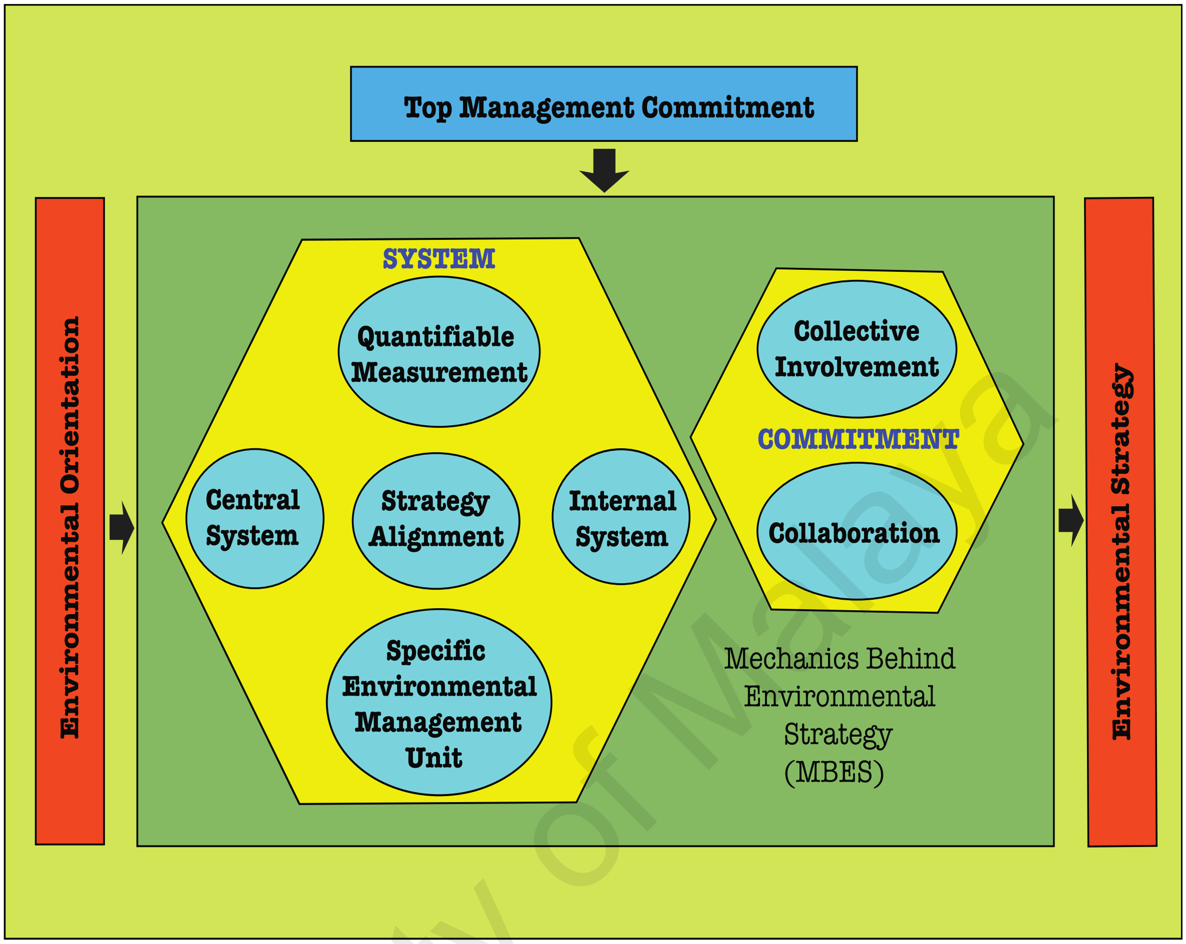

Figure 5.8 : Mechanics behind environmental strategies

Motivation and attitude projected by managers, on the other hand, were seen to slowly change firms' environmental behavior from being reactive to proactive (Carballo-Penela & Castromán-Diz, 2014). The interview results disclosed that firms are looking into local environmental issues and globally emerging issues. There has been a change of mindset; their take on environmental issues is at a greater level. Therefore, the success of the MBES has proven to be influenced by the commitment of the top management.

5.3.5 Relevant Issues

Two other issues that required due consideration in the future was apparent during the interviews. First, two drivers that could potentially influence EI are self-commitment, cost reduction and internal pressure. Second, there were several challenges that firms were facing to eco-innovate such as lack of exposure to the EI and poor policy direction.

5.3.5.1 Other Determinants

5.3.5.1.1 Self-Commitment

Self-commitment was observed as the driving force behind EI among large firms. Increasing level of environmental awareness has changed firm's mindset and encouraged them to adopt sustainable manufacturing practices. Protecting the environment has become part of their working culture. Large firms perceived that by instilling self-commitment towards the environment among the employees and within the organization contribute to better quality of cleaner production initiatives. Therefore, self-commitment from the following response clearly shows that firms have started to internalize environmental values and beliefs for long-term environmental benefits.

> *"Largely we have a huge commitment towards the society/community." (Respondent A2)*

> *"The organization wants to be environmentally responsible towards the society." (Respondent A5)*

> *"The level of self commitment is high towards the community." (Respondent A4)*

"Self initiatives strengthen the commitment towards cleaner environment." (Respondent A1)

5.3.5.1.2 Cost Reduction

During the interviews, informants directly or indirectly associated the promotion of EI initiatives with reduction in cost of production. Firms often view EI in light of business investment. Since, selling environmental projects to top management required a detail cost benefit analysis, in order for them to prioritize and provide funding for these projects. Therefore, the account of dollar and cents always matters when designing environmental strategies. Moreover, when asked whether do they merge their environmental strategies with their business strategies, the immediate answer from the respondents was "Yes". This shows that firms are not willing to compromise on their profitability.

"If the organization is taking steps to be environmentally sound, is because they want to reduce their operating cost and due to that reason itself they adopt some concepts of green industry." (Respondent A3)

"While moving towards a more sustainable path it indirectly helps us to reduce the cost."(Respondent A2)

"Setting the priorities and convincing the top management can be difficult. Cost benefit analysis need to be properly done to convince them as we are competing for the funds between various projects…at the end of the day dollar and cents matters…" (Respondent A1)

5.3.5.1.3 Internal Pressure

Internal pressure that arises within the group: subsidiaries, shareholders and joint ventures, were proven to be influential to stimulate EI. This budding pressure within the group forced the firms to envelope environmental strategies to improve their environmental performance.

“The group is strong, it emphasizes on the importance to protect the environment. The awareness to protect the environment and to adopt cleaner production practices has been there since 30 to 35 years.” (Respondent A1)

BASF: The group for a long time have been pressuring everyone to move towards cleaner production” (Respondent A5)

Internal pressure could have raised firm’s self-commitment to protect the environment and the initiatives to reduce cost through EI. However, the link between this emerging determinants and EI is unclear. Based on our observation there is no direct link between these determinants and EI. Another set on interview session is required to further gauge how imperative these determinants are on the connection to EI.

5.3.5.2 Challenges

Respondents highlighted several challenges that they face in greening their firms. First, there is no clear definition of green or cleaner production. The lack of comprehensive understanding of these concepts hinders the firms from formulating suitable strategies to transform their production processes. Furthermore, there is lack of proper benchmark of the green industry in Malaysia to emulate or assess their achievements.

“The definition of green or cleaner production is not clear in Malaysia, so we do not know what is exactly required from us.” (Respondent A5)

FC: “In Malaysia we don’t have a proper benchmark of green industry.” (Respondent A4)

Next, respondents expressed their disappointment on the dissemination of information regarding environmental incentives provided by the government. The information is frequently incomplete or not conveyed to the firms.

> *"If there are incentives, the information is not properly disseminated to us." (Respondent A5)*

> *"Information on green industry initiatives that are out there must be increased." (Respondent A3)*

> *"Very limited information on green initiatives." (Respondent A4)*

Lastly, a precise policy direction by the government to foster sustainable manufacturing practices is lacking. Due to unclear direction, firms find it difficult to determine suitable trainings for their employees and right mix of strategies to eco-innovate. Moreover, environmental consultants are charging high fees to assist firms in their green transformation. Therefore, respondents requested the government to monitor these expensive fees.

> *"To be environmentally responsible we need clear direction from the government because we need to train the workforce and design our action plan" (Respondent A5)*

> *"The consultants are charging very high fee…they need to be monitored." (Respondent A4)*

5.4 Discussion

5.4.1 Imperative EI Determinants

5.4.1.1 Environmental Strategy

Environmental strategy is a powerful EI determinant. Besides positively effecting EI (β = 0.292, $p < 0.01$) (see Table 7.7), environmental strategy was found to facilitate the relationship between four other determinants (environmental collaboration, green skills, consumer pressure and export behavior) and EI. Furthermore, the IPMA results (Model 3) (see Figure 7.3) indicated that environmental strategy has greater performance as compared to other EI determinants. The empirical results confirmed the qualitative findings that environmental strategy plays a key role in shaping firm's behavior and firm structure to eco-innovate. Additionally, all major determinants indicated strong relationship with the environmental strategy, directly or indirectly. Therefore, major key findings are closely related to environmental strategies. By taking into consideration findings closely related to mechanics behind environmental strategies (MBES) (see Section 5.3.4) and environmental strategies, discussion on the importance of environmental strategies is based on the following three facets: (1) firm structure and culture, (2) environmental integration and (3) top management commitment.

5.4.1.1.1 Firm Structure and Culture

According to Utterback (1971), the "effectiveness of firms in originating, developing, and implementing technical innovations is viewed as a function of three factors: (1)

characteristics of the firm's environment, (2) internal characteristics of the firm itself, and (3) flows between the firm and its environment". The exploration of the EI determinants in this study found that the second factor has greatly influence firms environmental strategies. These factors explained the firm structure and culture that influence the decision-making to eco-innovate (see Figure 5.9).

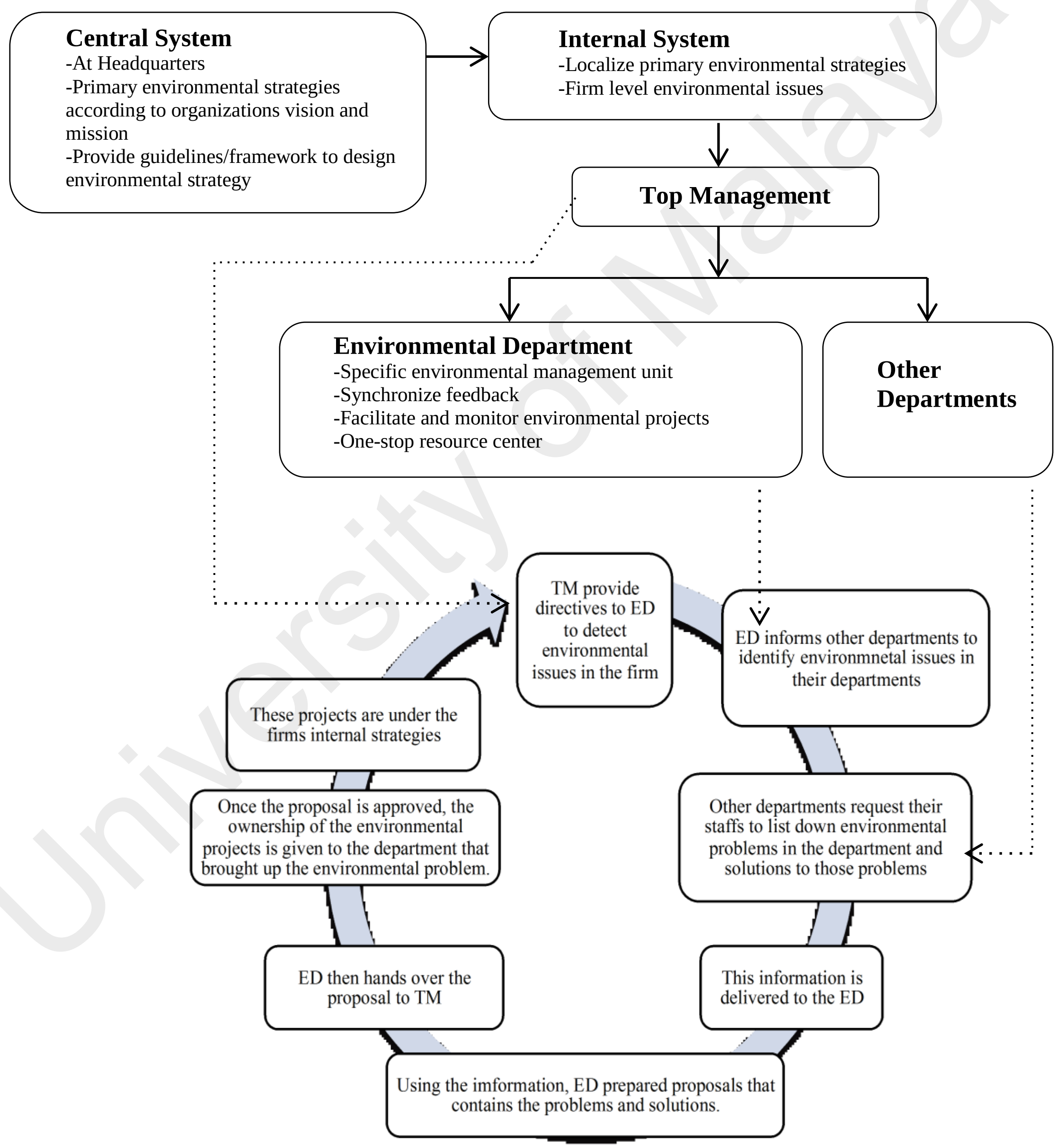

Figure 5.9 : Firm structure and the flow of decision-making
Note: TM=Top Management, ED=Environment Department
Source: Author

From the findings, there are two main systems that govern the entire process, which leads to EI, the central system and internal system. The headquarters governs the central system. The function of the central system is to formulate the primary environmental strategies while taking into consideration the vision and mission on the entire firm. A specific set of guidelines/framework is developed under the system, which facilitates other business units/subsidiaries when designing their internal environmental strategies and actions. Likewise, there is an internal system at firm level. The purpose of the internal system is to localize the primary environmental strategies in response to local regulatory needs and existing firm capabilities. The guidelines/framework provided by the central system is used to develop firm level strategies. Two main lead actors within the internal system that play an integral role to promote EI are the top management and a specific environmental management unit (i.e., environment department).

A standard flow transpires between the top management and environmental department (ED) to develop strategies to eco-innovate. First, the top management directs the ED to detect environmental issues in the firm. The ED informs heads other departments to report environmental problems in their departments. Then, the heads of the other departments instructs their staffs to list down environmental issues in their departments and solutions to those issues. The compiled information is then channeled to the ED. Using feedback provided by other departments; the ED prepares proposals for each environmental issue highlighted and submits it to the top management. This proposal contains a detailed cost and benefits analysis on the EI required to solve the environmental problem (i.e., firms frequently referred to the proposals as environmental projects). Upon approval, the ownership of the project is handed over to the department that highlighted the issues. The department is then responsible to execute the projects with the assistance from the ED.

There are several layers of decision-making involved to develop strategies to eco-innovate. The preliminary decisions are made at the department level, which involves the head of the department and the staffs. They decide on the integral issues in the department that needs immediate solution before informing the ED. Next, the ED decides on the most viable projects to be proposed to the top management for their approval, and the top management makes the final decision. Even though the top management exhibited an autonomy in decision-making on the EI, other departments are given a certain degree of autonomy to decide on the EI that requires due attention by the top management. Additionally, workshops and meetings were frequently conducted between the top management, department heads and employees to discuss environmental issues in the firm. Decisions made by the departments a totally based on the need for the respective EI, while decision made by top management is based on the urgency of the EI, financial viability and the return on investment (ROI).

By looking into the decision making process formalization was detected within the internal system, where the formulation of firm level strategies was based upon a set of guidelines/framework provided by the group/headquarters and the top management exhibited autonomy in decision-making. However, informal decision-making was detected within the departments, where staffs jointly discussed and decided on the EI that required attention from the top management. Formalization process is an important aspect within the internal system and for corporate greening to advance, formalization is necessary (Takahashi & Nakamura, 2005). It reduces headquarters' involvement (Roth et al., 1991) and gives a little autonomy to the firms to incorporate their ideas into the strategies (Hales, 1999), thus allowing firms to leverage on it to earn their competitive advantage. The firm structure and flow to design strategies to eco-innovate exhibited the concept of corporate environmentalism, which entails the amalgamation of environmental issues in the decision-making of a firm's business. Furthermore, projected path dependence process of how environmental strategies are created and incorporated into business strategy (Banerjee et al., 2003; Banerjee, 2001, 2002).

Besides the firm structure, the culture has played an important role in how the firms responded to the environmental issues. The approach taken by top management to design EI strategies and ensuring the success of these strategies has influenced the firm culture. First, the act of collaboration between top management, departments, and employees in designing EI strategies has provided liberty to employees to voice their opinions and accept environmental issues as a personal challenge. The responsibility given to the employees to list down environmental issues and solutions to those problems placed them into a learning process. This process provided them both the environmental awareness and technical ability to solve environmental issues. Based on the interviews, once the projects were approved, it was collective responsibility of the entire firm to ensure the success of the project. Furthermore, the involvement from the staff voluntary as caring for the environment is part of their corporate culture.

Organization and management studies have emphasized that the understanding of organizational factors, such as the culture and structure of a firm, are essential to understand how a firm reacts to external conditions and design solutions to solve their problems (Howard‐Grenville et al., 2008). The firm structure, whether it is formal or informal effects the decisions making process, which ultimately exhibit who has the autonomy to make decisions and the approach used in making those decisions (Howard‐Grenville et al., 2008). On the other hand, firm culture influences the actions taken by the firms in responding to varying issues and behavior (i.e., think and act) of the firm members (Frost, 1991). The knowledge of firm's structure and culture influence how a firm responds to external demand such as environmental policies. Developing a sound environmental strategy calls for changes in firm's routines and operations (Christmann, 2000). Plus every firm moves a long a unique managerial path. Therefore, actions proposed under government policies will not be achieved if they are unable to fit into the existing routine, which is influenced by the firms structure and culture.

Additionally, the centralized firm structure and formalization of the environmental strategy decision-making provided the basis that the top management directly deals with the ED. The ED is directly in communication with the heads of other departments especially from the production, operation, maintenance, technology/R&D and emissions reduction department. Therefore, for EI R&D to effectively take place, key personnel's from these departments plays an imperative role. This automatically creates a formal flow of communication and procedures are established between the ED and these departments (Howard-Grenville, 2006). Different external parties deal with personnel's from different departments, the effective interaction between these different departments is important to disseminate information provided by the external parties within the entire firm (Kivimaa, 2008b).

5.4.1.1.2 Environmental Integration

In public governance, "environmental policy integration" (EPI) is the act of integrating environmental concerns into every aspect of economic development and activities. The World Commission on Environment and Development viewed EPI as an integral approach for effective transition to sustainability. Since then, governments around the world embed the principles of sustainable in every department and coordinated their activities with sustainable development strategies (Jordan & Lenschow, 2008). Kivimaa (2008) proposed that EPI should not only be applicable to the government departments and development plans but extended within companies. Referring to it as "environmental integration", Kivimaa suggested environmental integration should take place vertically and horizontally within the firm. Where horizontal integration is to increase environmental concern and cooperation between environmental management and other departments within the firm. While vertical integration is to propagate corporate environmentalism within the firm to increase environmental performance. A matter of fact, a number of prior studies have long highlighted the importance of such integration especially for product development (Fryxell & Vryza, 1999; Lenox & Ehrenfeld, 1997). In this study, we found that environmental integration that shaped firms environmental strategies took place through (i) cross-functional integration between departments, (ii) top-down approach, (iii) environmental trainings and (iv) environmental knowledge databases. These four facets of environmental integration for environmental strategy formulation are discussed in detail in the following part.

i. Cross-functional integration between departments

Decision-making regarding environmental strategies involves various departments and personnel within the firm (Torre-Ruiz *et al*., 2015). Different departments are have different functional role to play, if not coordinated they will develop a different subculture (Howard-Grenville, 2006) and lead to functional disintegration (Fryxell & Vryza, 1999). Therefore, communication is crucial (Mårtensson & Westerberg, 2014) between this departments to streamline the entire system within a firm. Addressing the need coordinate and communicate environmental concerns, firms set up a specific environmental management unit (ED) (i.e., environmental department). Based on the findings, it was evident the ED is multifunctional. The top management primarily used this department to communicate the firm's environmental vision and mission with other departments. The ED was held responsible to coordinate all the other departments to create strategies to eco-innovate, by requiring every department to identify environmental issues in their department and the potential solution. This initiative automatically encouraged effective communication between departments as to develop EI it required expertise from different departments (i.e., manufacturing, environment, R&D and others).

According to firms, departments that mainly involved in the strategy formulation were from the production, operation, maintenance, technology/R&D, emission reduction and finance department. Additionally, the ED does not only bridge the communication gap between departments but also within the departments. This was executed by encouraging active communication within the department by encouraging the staffs of each department to identify environmental issues in their departments and the potential solutions through active discussion with their department heads. The active communication within the department was used as a channel to increase environmental awareness and provide trainings. Cross-functional integration is among the effective ways to promote unity of effort in firms by harmonizing organizational activities (Fryxell & Vryza, 1999) and assist tacit knowledge transfer (Kivimaa, 2008a).

ii. Top-down approach for corporate environmental strategies

Central system approach used in the firms to formulate firm environmental strategies is a conventional method (Fryxell & Vryza, 1999; Lawrence & Lorsch, 1986) used to coordinate firm environmental activities to eco-innovate. This system consists of selective experts from the headquarters to purposely design the primary environmental strategy to specific sets of guidelines/framework administer the entire strategy formulation process. Given the fact that the chemical industry is a highly risky and polluting industry, the headquarters seem to obtain certain control in the formulation of the environmental strategies. These centralized mechanics safeguard the firm's corporate image as claimed by scholars (Walley & Whitehead, 1994) and control the complexity that these firms have to deal with as they operate at multiple locations (Baligh et al., 1996) and ensures sustained environmental performance over time.

Comparable to the central system, firms (i.e., business units/subsidiaries) have an internal system. The internals system is based on similar principles promoted by the central system. The function of the internal system is to assists the firms to achieve the environmental strategies envisioned under the headquarters. Therefore, the firms have long-term and short-term environmental strategy. Long-term strategy is the primary environmental strategy initiated by the headquarters, while short-term strategies are the one developed at firm level. The short-terms strategies are smaller initiatives/environmental projects that lead to the achievement of long-term strategy. The formulation of the strategy is based on the guidelines/framework provided under the central system. However, when it comes to decision-making, even though it is centralized and the top management has greater autonomy as advised by the central system, there is a certain element of flexibility. Where the departments in the firm are given a little power to address the critical environmental issues in their department and to propose the potential solutions. For the environmental strategies, furthermore, firms set targets that are measurable and time-bound to assesse the success of the strategies. The setting of this quantifiable measures itself is according to a detail document provided by the central system. Energy intensity index and carbon reporting are among the measures used to gauge the success of their strategies. In conclusion, the central system was found to expedite the primary corporate environmental strategies within the firms. And the internal system facilitated the firms to design strategies to achieve the central strategy. The two systems ensured that the entire firm function according to one prime environmental agenda.

iii. Environmental trainings

Diffusion of environmental concerns was also executed through environmental trainings. Among the major agenda of the trainings was to create environmental awareness and provide necessary technical and non-technical skills to mitigate emissions. According to Lenox & Ehrenfeld (1997), environmental integration through the environmental training is strategic avenue for the management to communicate their environmental agenda and realign the firm capabilities for product development. The diffusion on environmental agenda took place either directly or indirectly. Direct approach was used when directives were given to employees to attend environmental trainings. Indirect approach was used when employees were actively engaged in decision making. Collective effort, self-realization, and continuous awareness were among the major three mechanisms used to instill environmental concern through training.

Collective effort mechanism took place when top management, department heads and employees were engaged to discuss environmental issues during meetings and workshops. This mechanism enabled the firm to bridge the environmental knowledge gap between the management and employees. Furthermore, it strengthened the bonding and increased the trust within the firm, which accelerated the commitment to increase firm's environmental performance. Interaction that transpired under the collective effort mechanism facilitated the transfer of codified and tacit knowledge from top management to employees, which is in fact a top-down integration effort (Kivimaa, 2008a). Next, self-realization mechanism was used to evoke the need for environmental commitment among employees. Community engagement programmes and problem-based tasks were among the activities used under this mechanism. These activities placed the employees into environmentally challenged situations and required them find solutions to those situations. Through these activities, employees valued the need for environmental commitment and to cooperate with the top management to solve environmental issues. Lastly, sharing environmental information on television, conducting 'Responsible Care' campaigns and posting information on the notice board were among the initiatives under continuous awareness mechanism.

Furthermore, firms have an evaluation system to encourage employee's participation and attention to engage in environmental trainings. Employees are evaluated through causal learning, monitoring and fulfillment of key performance indicators (KPI). For employees to effectively acquire knowledge and skills departed during the trainings, as a motivation promotion and pay rise are linked to the evaluation system.

iv. Environmental knowledge databases

Firms environmental knowledge obtained from internal or external sources are managed using environmental database (i.e., online sever system, filing system-documented information and others). The main function of the database is to design training modules for the employees and assist the formulation of environmental strategies. Environmental integration occurs via these environmental knowledge databases as the major environmental knowledge provider is the firms group. The group shares similar corporate environmental strategy and work in line with the guidelines/framework proposed by the central system. Firms obtain majority of the technical and non-technical environmental knowledge from the group. The environmental knowledge databases are easily accessible by all the departments in the firms.

5.4.1.1.3 Top Management Commitment

Top management commitment is the pillar behind the environmental strategy formulation, execution and success in the firms. The reason for the top management to exhibit high level of commitment could be due to pressure from the group/headquarters (Boiral *et al*., 2012). Influential top management commitment was seen present in the firms in setting up the flow and structure to encourage EI. Additionally, they were seen actively interacting with every quarter of their employees to promote the culture to increase the environmental performance of the firm. This gesture has the potential to build trust and enhance commitment (Ring & Van de Ven, 1994) among firm members, and this could be reason for employees to collaborate to plan environmental strategies for the firm. Furthermore, the establishment of a specific environmental management unit exhibited the commitment and importance that top management have placed towards environmental issues (Del Brío et al., 2001).

5.4.1.2 Foreign Influence

5.4.1.2.1 Export Behavior

Environmental standards and actions influencing the chemical manufacturing industry are largely according to the export-orientation of the industry. For Malaysia, this industry is the second largest exporter. The chemical industry is among the major industry that faced immense pressure for technological competition as it is exposed to new environmental issues and regulations (Faucheux, 2000). These international environmental regulations have imposed considerable pressure on Malaysia chemicals manufacturing firm. The ISO14001, REACH, EHS and RoHS are the major chemical related regulation that firms are currently complying. Firms expressed that it is a mandatory requirements for them to comply with these regulations to stay competitive. A list of countries that imposed stringent environmental regulation on Malaysian exports was obtained from the firms during the interviews. These countries were matched according to the environmental regulatory regime index (ERRI) score that ranked countries based on the quality of their environmental regulation system (C. Esty & Porter, 2001). Next, during the survey (i.e., quantitative), firms were required to state their major export destination. The percentage of firms exporting to these stringent environmental regulation countries was calculated (see Table 5.9).

Table 5.9 : Export to countries with stringent environmental regulation

Export destination	**Ranking (ERRI)**	**Percentage of firms**
Singapore	3	20.6%
European Union	Average 9.3	14.4%
-*Germany*	7	
-*France*	8	
-*United Kingdom*	13	
Japan	17	13.4%

Table 5.9 : Export to countries with stringent environmental regulation - continue

Export destination	Ranking (ERRI)	Percentage of firms
United States	14	9.3%
Korea	37	8.2%
Australia	16	7.2%
Malaysia	38	-

Note: Environmental regulatory regime index (ERRI) ranks countries based on the quality of environmental regulation system. The index includes regulatory stringency, structure, subsidies and enforcement sub index. To represent European Union the rank for there largest economy (GDP) was used (7+8+13=9.3). Total firms = 97

Source: Author and ERRI (Esty & Porter, 2001)

According to the ERRI, five out of the six countries that was listed by the firms are among the top 20 countries with stringent environmental regulation. Therefore, Malaysia would face a significant pressure from these industries to eco-innovate, with the major pressure coming from Singapore (20.6%), European Union (14.4%) and Japan (13.4%), as larger percentage of firms are exporting to those countries compared to others. Singapore is among the top five destination for Malaysia's chemicals and chemicals products export (MITI, 2014). Furthermore, the ERRI data is based on the 2001 global competitiveness report, which indicates that Malaysia's trade association with these countries has been for almost 15 years. In that time span, these countries would have imposed a considerable influence on Malaysian firms to increase their environmental performance.

Domestic firms that accounts for large exports have exhibited a positive relationship with environmental compliance (Christmann & Taylor, 2001). During the encounters of international trade, firms experience a certain behavioral change, which is influenced through knowledge and benchmarking information regarding environmental initiatives and advancement that is taking place globally. Firms that are involved in trade have greater tendency to raise their environmental performance (Lanoie et al., 2011). Using firm level data from Malaysia and Vietnam, Otsuki et al. (2015), studied the effects of REACH and

RoHS on exports. They found that compliance with these regulations increases the probability of export and assists the firms to penetrate into a wider market (i.e., countries). These could be the reason behind Malaysian firms with exports to countries with stringent environmental regulation indicated greater introduction of EI as compared firms with exports to countries with lax environmental regulation (see Table 5.2 and 5.3).

Despite exporting to countries with stringent environmental regulation, the percentage of firms exporting to countries with lax environmental regulation is higher comparatively. Among the main countries are China and Indonesia, at 39.2% and 36.1% respectively. However, Malaysia's ERRI is higher, at 38, as compared to China and Indonesia, which is at 44 and 54 correspondingly. The interview finding further indicated that Malaysia's environmental regulation and the enforcement initiatives taken by DOE are far superior compared to those countries. Nevertheless, according to the respondents, due to increasing pressure globally to reduce emission, China is also progressively taking initiatives to improve environmental performance.

5.4.1.2.2 Foreign Ownership

The findings indicated that from the 97 firms, 54.6% (53 firms) of the firms had foreign ownership (see Table 6.13), according to the following scales: 25% or less, 26%-50%, 51%-75% and 76%-100%; foreign ownership was 10.3%, 12.4%, 15.5% and 16.5% respectively. From the frequencies, it was evident that among the firms with foreign ownership, almost 58% of them had foreign ownership of 51% and above, which to a large extent is more than sufficient to influence the firm's decision-making. This information was calibrated with firm's headquarters location. Based on the details provided by the firms on the location of their headquarters, the study found that for 29.9% of the firms, their headquarters are in countries with relatively stringent environmental regulations namely: European Union, Japan, United States, Singapore, Korea and Australia (see Table 6.13). Additionally, according to Ministry of International Trade and Industry's annual report from 2009 to 2014, top ten approved manufacturing projects with foreign participatory by major source have been frequently from these countries (MITI, 2010, 2011, 2012, 2013, 2014).

The interview data firmly supported that foreign ownership has considerable influenced the firms to increase the environmental commitment and actively participate in greening their firms. Firms heavily depend on the group to obtain environmental knowledge. The group has a sophisticated knowledge database, which is centralized, structured and contains latest technical and non-technical information required to solve critical environmental issues. Furthermore, the guidelines/framework that is used to plan environmental strategies and action plans is also within this database. Additionally, firms are able to access professionals and technical experts from the database and request for their assistance. On the collaboration/networking front, the firms mainly collaborated within the group. The key areas of collaborations was R&D, trainings and for sharing best practices.

Therefore, foreign presence within the domestic firms has influenced major aspects of firm's innovative capability through the provision of knowledge resources and collaborations. The group is used as a channel by the foreign investors to infuse their environmental ideology. The group influences various determinants of EI found in this study (i.e., environmental strategy, green skills and environmental knowledge). Foreign presence has definitely influenced the local firm's behavior towards the environment and the environmental integration, and the level of EI that firms have achieved. A large number of studies have construed that a certain degree of foreign ownership within a firm especially in developing countries leads to greater probability for the firm to adopt international certification (i.e., ISO14001) (Fikru, 2014; Prakash & Potoski, 2007). Besides pressure from international linkages to adopt international certification, the diffusion or corporate environmental practices from the foreign affiliation is also a vital consideration. Furthermore, technological development in the Malaysian manufacturing sector, according to Chandran, Rasiah, & Wad (2009), is largely due to the strong foreign presence.

5.4.1.3 Environmental Regulation

The Environmental Quality Act, 1974 (EQA) is the major act that governs environmental issues especially for the manufacturing sector. Since the enactment in 1974, EQA has been revised and improved. Over the years, the enforcement approach has changed from rigor monitoring to a more flexible self-compliance approach. The Department of Environment (DOE) provides the firms with broad areas for compliance and requires the firms to provide the details of each areas according to their production mechanics. Since firms understand their own production mechanics, they were able to implement a customize pollution mitigation action plan. Therefore, this new approach is considered more effective.

The provision of more liberty and trust to the firms has increased their confidence towards the environmental regulation and the responsibility to comply with environmental standards required by DOE. Therefore, large firms were found to frequently submit the environmental reports according to the schedule. DOE is always informed if there are any emerging environmental issues in the plant that require immediate attention. Furthermore, the flexibility that the new system offer, led to effective negotiations between the firms and DOE.

However, besides offering a certain level of flexibility, the environmental regulation is extremely command and control in nature. While it is credited for pollution abatement but not for radical EI, firms are often inclined towards end-of-pipe technology under this approach (Stevens, 2000). For manufacturing firms, regulation (i.e., performance-based standards and technology-based standards) under the EQA 1974 emphasizes more on pollution mitigation actions that is directly associated with the production process. In general, environmental regulation in Malaysia has contributed to EI, but for process EI, firms are widely adopting end-of-pipe technologies. Among the firms, there is a greater level of adoption than creation for eco-process innovation; firms rather purchase these end-of-pipe technologies, as it is cheaper and available. In contrast, some firms are doing a lot more to protect the environment comparative to what is required by the environmental regulation. Some firms who are extremely committed to protect the environment regards that the Malaysian environmental regulation is still lax and the penalties imposed are relatively low comparative to other countries.

Problem in the administration of the environmental regulation was found to reduce its effectiveness. There is inconsistency in the enforcement of the new systems, the degree of flexibility and the ability to negotiate provided to the firms differ from one firm to another, leading to unfair treatment. Since, the officers who are responsible for a particular regulation and firm keep changing; firms frequently have to deal with new regulators who are not familiar with the firms' manufacturing process, and sometimes their action and interpretation of the regulation is inconsistent as compared to the former officers.

5.4.1.4 Consumer Pressure

For a long time now, the chemicals industry have been under scrutiny due to its high polluting track record and there is an extreme pressure globally for the industry to adopt environmental friendly practices (Faucheux, 2000; Hoffman, 1999; Røyne et al., 2015). The chemical manufacturing industry sub-sectors are complex and heterogeneous. The sub-sectors are rigorously interlinked, where product of one sub-sector serves as raw material to another sub-sector. Therefore, the chemical manufacturing industry is its own biggest buyer as well as seller. Moreover, the chemical industry exhibits strong backward and forward linkages between other sectors in the economy (Lee, Mokhtar, Goh, Singh, & Chan, 2015; MPC, 2015). By looking into these linkages and increasing pressure, the main parties pressuring the chemical manufacturing industry are buyers from within the industry, other industries and international consumers.

5.5 Summary

The purpose of this chapter was to assess the state of eco-innovation and the underlying forces that contribute to EI and understand the dynamics and structure of the EI. From the literature, nine EI determinants that were perceived potential to stimulate EI was identified. These determinants were explored using six case studies, which were carried out in large chemical manufacturing firms. The main purpose was to explore their relevance, mechanic and linkages.

First, in terms of state of EI, the findings revealed that firms are actively involved in all three types of EIs. However, organizational EI has been the most promising and actively executed innovation by firms. Greater level of creation is involved in producing this type of EI as compared to other types of EI, and chain management is receiving increasing attention. Besides, process EI firms prefer adoption as there are a lot of cheaper options available in the market. This is relatively a more cost effective option for firms compared to creation. Finally, product EI is gaining popularity among firms due to increasing demand by consumers. Firms also believe that in order for to remain competitive, they have to venture into green products. In a nutshell, firms are triggering all three types of EIs. They are using organizational innovation to integrate every environmental aspect in organization to maximize the outcomes of these EIs. Therefore, firms have acknowledged the importance of interconnectedness between each type of EI for long-term sustainability and greater environmental performance. Additionally, for the introduction of EI, foreign influence was an extremely important driver. Firms with foreign ownership, foreign headquarters location and exports to countries with stringent environmental regulation exhibited greater introduction of EI as compared to firms with domestic ownership, domestic headquarters location and exports to lax environmental countries. Countries with greater foreign influence also projected higher creation of EI then the domestically inclined firms.

Second, for EI determinants, based on the interviews all the nine indicators are important drivers of EI. However, the striking findings to emerge from the interviews are that majority of the determinants did not exhibit a direct link with EI and there are three models that integrate these eco-drivers. Model 1 is the resource model, which influence the level of green skills in the firms. Green skills are driven by environmental knowledge and environmental collaboration that firms have established over the years. This model is later connected to the second model, which is the strategy model through green skills. Market pressure, export behavior, green skills and environmental collaboration are determinants that directly influenced firm’s environmental strategies. The strategy model is an integral part of the entire model as it bridges the gap between resources and capabilities to design effective environmental strategies to promote EI initiatives. Strategy model is connected to model 3 through a direct link between environmental strategy and EI. Another three determinants namely: environmental regulation, financial resources and regulation stringency were observed to directly relate to the EI model (model 3). Additionally, most of the indirect relationship exhibited by the determinants with EI is through environmental strategy mediate. These three models were incorporated to provide a holistic EI framework for the chemical manufacturing industry.

Third, the reason for stating that environmental strategy is an imperative EI determinant is due to the observation of strong mechanics, which guided the formulation, design and implementation of environmental strategies. These mechanics are referred as the mechanic behind the environmental strategies. The findings suggest two pertinent components of MBES: system and commitment. System encompasses five important mechanics that provide the working flow in transforming environmental issues into strategies, namely, central system, internal system, specific environmental management unit, measurement and strategy alignment. Central system governed by headquarters or group that transforms the organizational vision and mission into primary strategies. This system facilitates the firms in dealing with environment issues using a guided framework developed under the central system. Likewise, there is an internal system at firm level. Using the guided framework provided by the central system, detecting and transforming the environmental issues into actions through active interaction within the organization are the main purpose of this system. Next, there is a specific environmental management unit in the system, which serves as a one-stop center to get environmental-related information, provide feedback, and plan environmental initiatives, and to manage these initiatives. Moreover, firms set targets that are measurable and time-bound so that the success of the strategies can be assessed and improved. Lastly, to retain their competitive advantage, frequent strategy alignments are done to incorporate globally emerging environmental issues into their strategies.

On the other hand, collaboration and collective involvement fall under the second category. Collaboration between top management, departments and employees has been the backbone of environmental strategy formulation and design. Top management has implanted a strategy formulation procedure within the organization that automatically involves every organizational member in the process. Additionally, this mechanism provides on-the-job learning platforms for the employees, especially environment-related. Next, collective involvement among employees was found in the implementation of these strategies. However, the upper layer of the management portrayed a higher level of commitment compared to the bottom layer. Feedbacks suggest that this difference might be due to the low level of education background of the latter group. Another important point is that the MBES initiation and binding depends on the strength and influence of the top management commitment.

Next, three other determinants were observed to influence EI, which are self-commitment, cost reduction and internal pressure. The initiation of self-commitment and cost reduction was seen through external pressure stemming from firms group, subsidiaries and joint ventures. However, the link between this determinants and EI is still not clear. The interviews did not clearly indicate the link between these drives and EI. Lastly, firms highlighted several challenges encountered to eco-innovate. They expressed that there is no clear definition of EI and proper benchmark of green industry. This hinders from planning suitable strategies to mitigate pollution because there are unsure about what is the threshold for their green initiatives. High fees imposed by environmental consultants and ineffective dissemination of information related to government environmental incentives are among other challenges brought forward by respondents.

CHAPTER 6 : QUANTITATIVE RESEARCH DESIGN

6.1 Introduction

This chapter presents the conceptual framework and the research methodology that was employed to evaluate the hypothesis. Additionally, description regarding the research procedures used to finalize the survey instrument, methods used to collect and data management, and the technique employed for analysis is part of the chapter's content.

6.2 Exploratory Eco-Innovation Framework

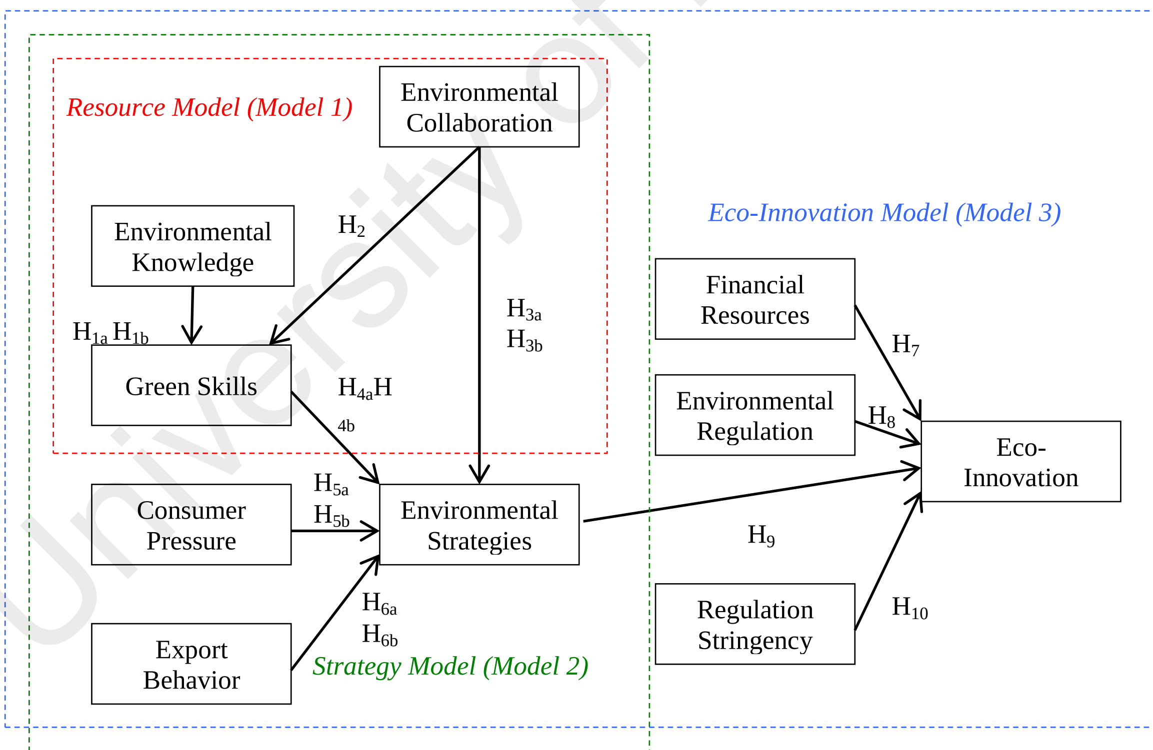

Figure 6.1 : Exploratory eco-innovation framework

Drawing upon previous literature and interview findings, this study structured an interconnected EI framework to examine the EI determinants. Figure 6.1 exhibits a refined EI framework that encapsulated the determinants and their hypothesized linkages.

6.2.1 Research Hypothesis

With reference to Figure 6.1, this section briefly summarizes knowledge from the literature and interview findings to present the research hypothesis for model 1, model 2 and model 3. Detail information on previous literature and findings that were used to coin the preliminary hypothesis can be obtained from Chapter 2. And discussion on the interview findings that refined the hypothesis could be view from Chapter 4. The summary of preliminary hypothesis is available in Table 2.5.

6.2.1.1 Resource Model (Model 1)

Model 1 comprises of three EI determinants: environmental knowledge, environmental collaboration and green skills. This model is referred as the resource model because it contributes to the incorporation of the most imperative resource, which is the knowledge required for developing green skills among employees. Initially, the literature provided some basis to hypothesize a positive direct relationship for two EI determinants, environmental knowledge (Shin et al., 2008; Zhou & Li, 2012) and environmental collaboration (De Marchi, 2012; Triguero et al., 2013) with EI.

Based on the interview findings, however, both environmental collaboration and knowledge did not reveal any prominent direct relationship with EI. These two determinants were observed to strategically build employee green skills. Firms are dependable on these two channels to acquire advanced environmental knowledge for environmental management (Shin et al., 2008) and develop training modules for their employees (Evans & Stroud, 2016). Therefore, this study contends that both environmental knowledge and collaboration is positively associated with green skills.

H_{1a}: Environmental knowledge positively influences green skills.

H_2: Environmental collaboration positively influences green skills.

6.2.1.2 Strategy Model (Model 2)

Strategy model (Model 2) is the heart of the entire EI framework. According to the interviews, four EI determinants, which are the environmental collaboration, green skills, consumer pressure and export behavior exhibit positive direct relationship with environmental strategy. In the literature search, even though environmental knowledge, green skills (Cainelli et al., 2012), market pressure (Nesta et al., 2014; Ziegler & Rennings, 2004) and export behavior (Christmann & Taylor, 2001; Lanoie et al., 2011) exhibit positive direct relationship with EI, there was always indication that these determinants have an indirect relationship with EI. The interview results strengthened this pre indication. The technology push and demand pull factors reconfigured firms working culture and dynamism to better tackle environmental problems. Thus, firm's internal resources and capabilities are collectively gathered through environmental strategies, which later promoted EI. Literature supported that skills and knowledge assist in generation of ideas and plans to consolidate firm's resources and capabilities to battle rising environmental issues (Leiponen, 2005; Shin et al., 2008). Additionally, local and international pressure contributes to positive behavioral change among firms to increase their environmental performance. For market pressure, according to the interviews, pressure stemming from consumers is extremely great comparative to competitors. Therefore, for this study, attention is given to consumer pressure.

In contrast to direct relationship, an indirect relationship between environmental knowledge and environmental strategies through green skills was observed. Firms absorbed knowledge and experience through their employees. These experienced and resourceful employees generate ideas and formulate plans to solve organizational environmental issues. Furthermore, strategy model connected all three models. Based on the discussion above, the following hypotheses are set forth:

Direct relationship

H_{3a}: Environmental collaboration positively influences environmental strategies.

H_{4a}: Green skills positively influence environmental strategies.

H_{5a}: Consumer pressure positively influences environmental strategies

H_{6a}: Export behavior positively influences environmental strategies.

Indirect relationship

H_{1b}: Environmental knowledge indirectly influences environmental strategies through green skills.

6.2.1.3 Eco-Innovation Model (Model 3)

Eco-innovation model is the largest model compared to the other two models. This model exhibits two types of relationship between the determinants and EI. Financial resources, environmental regulation, environmental stringency and environmental strategies contribute to direct positive relationship with EI. According to the literature and interviews, environmental regulation (Lee et al., 2011; Naoilly, 2012) and regulation stringency (Johnstone et al., 2012; Kerr & Newell, 2003) indicated a consistent direct positive relationship with EI. For financial resources, literature provided some basis for direct positive relationship with EI (Painuly et al., 2003). However, observations from the interviews strengthened this relationship as the top management of firms is directly involved in scrutinizing and approving funds for eco-innovation R&D.

Environmental strategies, on the other hand, directly influence EI (Gerstlberger et al., 2014) assisted the indirect relationship, whereby, environmental collaboration, green skills, consumer pressure and export behavior indirectly influence EI through environmental strategies. The EI literature and interview data recommend that these determinants congregate firm's resources and capabilities via environmental strategies to promote EI. In sum, EI is generated through a direct and indirect linkage, leading to the following hypothesis:

Direct relationship

H_7: Financial resources positively influences eco-innovation

H_8: Environmental regulation positively influences eco-innovation.

H_9: Environmental strategies positively influences eco-innovation

H_{10}: Regulation stringency positively influences eco-innovation

Indirect relationship

H_{3b}: Environmental collaboration indirectly influences eco-innovation through environmental strategies.

H_{4b}: Green skills indirectly influence eco-innovation through environmental strategies.

H_{5b}: Consumer pressure indirectly influences eco-innovation through environmental strategies.

H_{6b}: Export behavior indirectly influences eco-innovation through environmental strategies.

6.3 Measurement and Instruments

The previous section incorporated three models to develop a comprehensive EI framework. The exploratory EI framework integrated EI determinants from three different standpoints: resource, strategy and EI. This section aims to describe the measurements and instruments used to test the hypothesized relationships among the constructs in the EI framework. The measurement instrument was developed based on the review of extant literature, interview findings and established research surveys. This is because there is no comprehensive research survey to assess EI and its determinants. The measurement scales for the items are adapted from previous studies accordingly. The description of each construct from the literature review (i.e., from Chapter 2) is presented again in Table 6.1, to ease the process of understanding the constructs and items.

Table 6.1 : Construct description

Construct	Description	Source
Green skills	Skills that help mitigate adverse environmental effects of human activity towards the environment.	(Martinez-fernandez & Hinojosa, 2010)
Environmental knowledge	Knowledge required for planning and refining technological process and structures, which alter the full stream of physical sustainability objects such as the production system to serve a more eco-friendly purpose.	(Shin et al., 2008)
Environmental collaboration	Collaboration that takes place when more than two organizations join forces to share information, make joint decision, and share their best practices to mitigate adverse environmental effects of human activity towards the environment. *Adapted from green supply chain management.	(Simatupang & Sridharan, 2002, 2005)
Environmental strategy	"A strategy that manages the interface between its business and the natural environment".	(Aragón-Correa & Sharma, 2003, p. 71)
Export behavior	Firm's response towards foreign environmental regulation specifically imposed on their exports and behavioral change that takes place by interacting with trading partners who are concerned for the environment. *Brought together by reviewing studies that explored the role of export in favour of eco-innovation.	(Brunnermeier & Cohen, 2003; Christmann & Taylor, 2001; Horbach, 2014)
Consumer pressure	Market pressure specifically stemming from consumers who are concerned about the environment and demand for eco-friendly products.	(Reinstaller, 2005)
Environmental regulation	1. Command and control regulations (CAC) are prescriptive in nature. They tend to force the firms to strictly comply with regulatory requirement set by the authority. Examples of CAC are performance-based standards and technology based standards. 2. Market-Based Instruments (MBI) are flexible in nature. They respond to market signal rather than strict directives from any pollution regulatory authority. Examples of MBIs are pollution charges, tradable permits, and market friction reductions. 3. Government incentives for firms to embark on eco-innovation projects and to promote energy conservation. Examples of government subsidies are R&D subsidies, innovation subsidies, tax reduction for environmental innovation, and energy conservation credits	(Fischer et al., 2003; Magat, 1979; Popp et al., 2010)
Regulation stringency	"How ambitious is the environmental policy target, relative to the 'baseline' trajectory of emission"	(Johnstone et al., 2010).
Financial resources	Resources specifically allocated for investment in eco-innovation activities. For example eco-innovation R&D, purchase end of piping technologies, and funding of environmental protection projects.	(del Río, 2009)

6.3.1 Eco-Innovation

There are a number of ways to measure EI. The two most commonly used methods are intermediate output measures and research surveys. Intermediate output measures utilizes patent or scientific publication data to measure eco-innovation (Johnstone, Haščič, Poirier, Hemar, & Michel, 2012; Popp, 2005; Yabar, Uwasu, & Hara, 2013). However, there is lack of green patents (Aghion et al., 2009) and it is difficult to differentiate between general innovation and environmental innovation patents. Environment specialized surveys is another measure that has gained greater attention since the last two decades. This surveys consists of either large databases such as community innovation survey (CIS) (De Marchi, 2012; Ghisetti et al., 2015b; Horbach, Oltra, & Belin, 2013) and European Business Environment Barometer (EBEB) survey (Wagner, 2008), or self-structured questionnaire surveys (Boiral et al., 2012; Cuerva, Triguero-Cano, & Córcoles, 2014; Kammerer, 2009). Presently, CIS database is widely used by various research. Despite suffering from reliability and validity issues, surveys are extremely popular among research due to its ability to gauge various aspects of EI such as drivers, barriers and regulation implications. For the purpose of this study, survey research method was finalized because sophisticated data on environmental technology patents or expenditure on cleaner production technologies in the Malaysian context is unavailable.

Study by Kemp & Arundel's (2009) provided extensive report on measuring EI, which relied extensive research to determine the items to measure the three types of EI: process, product and organizational. In their report, Kemp & Arundel classified EI into four categories: environmental technologies, organizational innovation, product and service innovation and green systems innovation. However, this study focuses on the first three classifications as the last classification of EI is still at an infancy stage and yet to gain popularity in the developed countries, thus it was not deemed suitable for the context of this study in a developing country. The interview findings further supported that this category is still irrelevant in Malaysia. Therefore, EI was measured using three dimensions, which are process, organizational and product. Twelve items were used to measure EI, whereby; process EI dimension consists of six items, while organizational EI and product EI dimension consist of three items each (see Table 6.2).

List of EI provided by Kemp & Arundel for each category was discussed with environment consultants in Malaysia to verify their availability and applicability for chemical manufacturing industry in Malaysia. The consultants were also requested to provide some examples of EI that are available in the market, technology types are supported with examples to ease respondents in answering the survey. For product EI, information from CIS questionnaire (Eurostat, 2008) was used to refine the items. A binary scale (Yes/No) was used to determine the introduction or significant improvement of a specific type of EI as it is a simple and reliable scale (OECD and Eurostat, 2005).

With regard to the type of EI, intensity of the EI was also examined by obtaining information on whether the EI is a creation or adoption. Creation is referred to a newly developed EI by firms, which either replace or complement the existing innovation (Altmann et al., 2011). While adoption is referred to the employment of EI that is readily available in the market, which is customize to suit firms production specifications (Khanna et al., 2009). For this section, if firm acknowledged that they have introduced a new or significantly improved EI, they are then required to determine whether the EI is a creation or adoption.

Table 6.2 : Measurement scale and items for eco-innovation

Construct	Item (Scale -Yes/No if yes then determine Creation/Adoption)		Reference
Process EI	EP1	Cleaning technology that treat pollution released into the environment: Pollution control technologies for air, water & soil (Scrubbers/dust collection system/waste water treatment)	(Eurostat, 2008; Kemp & Arundel, 2009) Environment consultants Interviews
	EP2	Cleaner process technologies: New manufacturing processes that are less polluting and/or more resource efficient than relevant alternatives	
	EP3	Waste management technologies /equipment's (Incinerators/ recycling equipment)	
	EP4	Environmental monitoring technologies and instrumentations	
	EP5	Noise and vibration control technologies	
	EP6	Green energy technologies (solar/wind/bioenergy)	
Organizational EI	EO1	Pollution reduction/prevention schemes that address source reduction, reuse and recycling, and energy consumption: Which eliminates wasteful management practices	
	EO2	Formal systems of environmental management involving measurement and reporting. For example ISO 14001, EMAS and others	
	EO3	Chain management: cooperation between companies so as to close material loops and to prevent environmental damage across the value chain	
Product EI	EPR1	New environmentally improved products or services for end users	
	EPR2	Products that will have lower emissions when used	
	EPR3	Products that are more energy efficient	

6.3.2 Regulation Stringency

Researchers deployed several imperfect proxies to measure environmental regulation stringency. Among the common proxies are pollution abatement and control expenditure (PACE) (Jaffe & Palmer, 1997; Johnstone et al., 2012; Wagner, 2007), frequency of environmental inspection visits (Brunnermeier & Cohen, 2003) and other forms of regulatory expenditure databases, for example the Environmental Protection Agency (EPA) (Lee et al., 2011).

For the case of Malaysia, the closet available proxy is PACE. However, the data is not suitable because the data is not provided at firm level but at industry level. Due to these shortcomings, survey questions were used to measure the perceived stringency that was measured with three items using a 7-point Likert scale. To provide reinforcement to measure the construct, two dimensions were used to support the direct item that gauges the perceived stringency. The two dimensions are enforcement and monitoring. Government enforcement and monitoring is expected to increase firms pollution abatement expenditures (Brunnermeier & Cohen, 2003). Item C1 was adapted from executive opinion survey 2009 (Porter & Schwab, 2010). While item C2 and C3 was inspired by Brunnermeier & Cohen (2003) and was constructed based on the interview information (see Table 6.3).

Table 6.3 : Measurement scale and items for regulation stringency

Construct	Item (7-point Likert scale)		Reference
Regulation stringency	RS1	How would you assess the stringency of the environmental regulations in Malaysia?	(Brunnermeier & Cohen, 2003; Porter & Schwab, 2010) Interviews
	RS2	How would you assess the enforcement of the environmental regulations in Malaysia?	
	RS3	How would you assess the level of monitoring on your environmental activities by regulators (for example plant inspection and environmental report submission requirement)?	

6.3.3 Environmental Regulation

Quantitative researchers have deployed various techniques to measure environmental regulation. Some have used secondary data to measure environmental regulations, for example, energy prices, government R&D expenditure (Naoilly, 2012), tradable permits (Kerr & Newell, 2003) and others. Whereas, some have used primary data collected using a research survey to measure environmental regulations (Cleff & Rennings, 1999; Wagner, 2008). Majority of studies that choose this route to measure environmental regulations use binary scale. This binary variable takes the value of 1 if environmental regulations have been effective to encourage firm to invest in environmental mitigation plan (Demirel &

Kesidou, 2011). Researchers that used the both primary and secondary techniques to measure environmental regulations have frequently addressed their shortcomings. Thus, there are no perfect techniques to measure environmental regulations; researchers deploy a certain techniques depending on the availability of data.

Table 6.4 : Measurement scale and items for environmental regulation

Construct	**Item (7-point Likert scale)**		**Reference**
Environmental regulation	ER1	To what extent does your enterprise generate innovation with environmental benefits in response to the existing environmental regulations or taxes on pollution?	(Eurostat, 2008; Horbach et al., 2012)
	ER2	To what extent does your enterprise generate innovation with environmental benefits in response to the environmental regulations or taxes that are expected to be introduced in the future?	
	ER3	To what extent does your enterprise generate innovation with environmental benefits in response to the availability of government grants, subsidies or other financial incentives?	

For this study, a research survey approach was selected. The CIS (Eurostat, 2008) items related to environmental regulations were adapted and the binary scale was expanded to a 7-point Likert scale (see Table 6.4). This is because from the interviews, it was observed that environmental regulations strongly influence their level of EI and regarded the new regulatory system better. Large firms were also found to religiously complying with all the regulations. However, there are firms who acknowledge that they doing a lot more to protect the environment as compared what is required by the authority, not understanding that the pollution mitigation threshold is determined by the authorities. During their initial start-up years, they have to follow mitigation plan provided by DOE. During the interviews, the response towards environmental regulation related questions was based on how the regulation has favored them in the past. If the regulation has treated them fairly then their response are positive and vis-à-vis. Therefore, a seven-point Likert scale was deemed more suitable, as firm's can weight the impact that regulation has on their environmental behavior.

6.3.4 Green Skills

Researches have not used a comprehensive instrument to measure green skills. A common technique used by quantitative researchers is the share of trained employees over total employment (Cainelli et al., 2012; Horbach, 2008) or CIS database. Jose et al., (2015) acknowledged that researchers are aware that green human resource management is imperative for the adoption of advanced EI, but still there is no single inclusive tool to measure green skills. Three aspects of employee development that is worthy of extra attention to promote innovation is trainings, employee empowerment (Altmann et al., 2011) and performance appraisal (Chen & Huang, 2009). For this study, a research survey was finalized to measure green skills, which was established based on the three dimensions.

During the interviews, these three aspects were emphasized to obtain information related to the main aspects of green skills. The interview results revealed that green trainings are integral part of employee development. Additionally, respondents highlighted that the employee's absorptive capacity to internalize and apply these skills is heightened when they are equipped with adequate environmental awareness. The findings also revealed that there is a performance assessment system, which is linked to pay rise and promotion. Thus, the literature inspired the dimensions to measure the construct and the interviews assisted in designing the four items used to measure green skills (see Table 6.5).

Table 6.5 : Measurement scale and items for green skills

Construct	Item (7-point Likert scale)		Reference
Green skills	GS1	To what extent does your enterprise invest in training and employee development specifically in the area of environment?	(Altmann et al., 2011; Chen & Huang, 2009) Interviews
	GS2	How would you assess the effectiveness of your enterprise's efforts in ensuring that employees are provided adequate environmental awareness?	
	GS3	To what extent does your enterprise assess employee's contribution/involvement in improving the environmental performance?	
	GS4	To what extent does your enterprise reward employees for environmental improvement through promotion and pay rise?	

6.3.5 Environmental Collaboration

For the purpose of this study, environmental collaboration is defined based on three dimensions as proposed by Simatupang & Sridharan (2005), which was used to develop a collaboration index to measure supply chain collaborations. The dimensions are sharing of information, making joint decisions and sharing of benefits. During the interviews, these dimensions strongly emerged, when issues pertaining to environmental collaboration were extracted from the respondents.

Table 6.6 : Measurement scale and items for environmental collaboration

Construct	Item (7-point Likert scale)		Reference
Environmental collaboration	In your enterprise, how extensive are the collaboration and networking among groups, firms, suppliers, partners, and associations with regard to the following:		(Dai et al., 2014; Simatupang & Sridharan, 2005) Interviews
	EC1	Obtain knowledge/information/expertise related to environmental issues?	
	EC2	Make joint decisions on environmental issues?	
	EC3	Share enterprise's best environmental practices?	

Therefore, a research survey comprising of three items closely related to the three dimensions was chosen to measure environmental collaboration (see Table 6.6). Items used by Dai, Montabon, & Cantor (2014) to measure the collaboration with suppliers environmental issues, which was also based on the three dimensions was adapted accordingly to suit this study.

6.3.6 Environmental Knowledge

A research survey, the frequently used method to measure environmental knowledge was deployed (Lenox & King, 2004; Shulz, 2001; Simpson, 2012; Zhou & Li, 2012). In order provide robustness to the measure of environmental knowledge four dimensions was incorporated. Simpson (2012) emphasized that employee's need to be regularly educated, for that purpose continuous upgrading of knowledge and proper storage of this knowledge is required. This information provided the basis for the first two dimensions, which is knowledge upgrading and knowledge management.

Table 6.7 : Measurement scale and items for environmental knowledge

Construct	Item (7-point Likert scale)		Reference
Environmental knowledge	EK1	How would you assess the effort of your enterprise to continuously update its environmental knowledge/information (for example volatile organic compound (VOC), list of hazardous chemicals, technical information, procedures, environmental regulations etc.)?	(Shulz, 2001; Simpson, 2012; Zhou & Li, 2012) Interviews
	EK2	Does you enterprise have an environmental information management system to store environmental information (for example an internal server system, soft copy, manual filing etc.)?	
	EK3	How easy is it to access the environmental information management system in your enterprise?	
	EK4	How would you assess the quality of the flow of environmental information between every managerial level in your organization?	

On the other hand, Zhou & Li (2012) and Shulz (2001) highlighted the importance of knowledge sharing throughout the organization. This information led to the third and fourth dimension, which is the quality of knowledge shared and the accessibility to this knowledge. Four items, each representing one dimension was used to measure environmental knowledge. Table 6.7 presents the items that was adapted and adjusted according to the interviews to provide more depth and breath.

6.3.7 Environmental Strategies

Environmental strategy is usually measured through self-perception because data regarding firm's environmental performance is not publicized (Aragón-Correa et al., 2008). Therefore, colossal amount of empirical studies that measured environmental strategies are used as a research survey (Aguilera-Caracuel, Hurtado-Torres, & Aragón-Correa, 2012; Aragón-Correa et al., 2008; Betts et al., 2015). For this study, this was the suitable technique due to the unavailability of data on firm's environmental strategies initiatives.

In this study, five items were used to measure environmental strategy. The items was adapted from Menguc et al. (2009). The Five items were selected based on the main environmental strategy dimensions detected during the interview. The first dimension is waste management. Firms in Malaysia are still underlining strategies in the waste management area, and probing relevant information and technologies to reduce their waste generation. Items ES3, ES4 and ES5 shown in Table 6.8 are classified under this dimension. The next dimension is the top management's commitment. The interview results indicated that the top management's commitment consolidates resources and capabilities of the firms to formulate environmental strategies, thus item ES1 is devoted to this dimension. The final dimension is specific environmental management unit. Item ES2 was established based on observation during the interviews, where a proper environmental strategy was the result of a well-structured environmental management unit. From the interviews, it was evident that items related to these three dimensions are imperative to capture firm's environmental strategy.

Table 6.8 : Measurement scale and items for environmental strategies

Construct	Item (7-point Likert scale, 1-strongly disagree, 7-strongly agree)		Reference
Environmental strategies	ES1	To what extent does your top management communicate that addressing environmental issues is critical?	(Menguc et al., 2009) Interviews
	ES2	Who primarily handles environmental related issues in your enterprise?	
	ES3	How would you assess the effort of your enterprise in eliminating the release of any substances that cause environmental damage?	
	ES4	How would you assess the effort of your enterprise to eliminate the use of products that cause environmental damage?	
	ES5	To what extent does your enterprise dispose physical waste through environmentally safe methods?	

6.3.8 Consumer Pressure

Table 6.9 exhibits the measurement scale and the two items that was adapted from Sarkis et al. (2010) and Dai et al., (2014) to measure consumer pressure. Interview findings suggested that firms are highly responsive to consumer pressure. Therefore, item CP1 was constructed to strengthen the measurement by requesting the respondents to rate the level of environmental awareness among their customers, which indirectly indicates the pressure encountered.

Table 6.9 : Measurement scale and items for consumer pressure

Construct	Item (7-point Likert scale)		Reference
Consumer pressure	CP1	How do you rate your customers' awareness towards environmentally friendly products?	(Dai et al., 2014; Sarkis et al., 2010) Interviews
	CP2	How would you rate the pressure that your enterprise encounters to generate environmental benefits stemming from consumers?	

6.3.9 Financial Resources

Items used to measure financial resource through a research survey was adapted from Savignac (2008) and Stoneman & Canepa (2002) (see Table 6.10).

Table 6.10 : Measurement scale and items for financial resources

Construct	Item (7-point Likert scale)		Reference
Financial resources	FR1	To what extent slowness in setting up financing is a barrier for your enterprise to execute environmental projects/activities/ innovations?	(Savignac, 2008; Stoneman & Canepa, 2002)
	FR2	To what extent high cost is a barrier for your enterprise to execute environmental projects/activities /innovations?	
	FR3	To what extent is the no financing source a barrier for your enterprise to execute environmental projects/ activities/ innovations?	

6.3.10 Export Behavior

Majority of the empirical research that suggested exporting firms to be more environmentally concern used a dummy variable as a proxy for export, which takes the value of one if a firm is exporting or with a higher export share (Ghisetti et al., 2015b; Horbach, 2008). However, for the purpose of this study, dummy variable was not a suitable measure of export behavior for two main reasons. First, the data was analyzed using PLS, thus a single binary variable is not suitable under PLS conditions. Second, through the interview, export behavior was found to eminently affect firm's environmental strategies. Hence, items that could capture international influence on firms export behavior are more suitable. To measure export behavior, a research survey was used. Based on the interviews, two items were developed to measure export behavior (see Table 6.11).

Table 6.11 : Measurement scale and items for export behavior

Construct	Item (7-point Likert scale)		Reference
Export Behavior	EB1	To what extent does your enterprise's foreign buyers require you to comply with their environmental regulation/requirement (for example: ISO14001, REACH, RoHS, chemical labeling and others)?	Interviews
	EB2	To what extent does your foreign buyers' environmental regulations influence your enterprise's environmental and business decision-making?	

6.4 Construct reliability and validity

The measurement instrument is developed depending on multiple sources of information. Therefore, to ensure that the instrument provides consistent results and measures what it is intended to measure, both the reliability and validity of the instrument need to be assessed (Carmines & Zeller, 1979). This section explains the reliability analysis, content validity and face validity that was performed to strengthen the instrument.

6.4.1 Reliability test

Reliability analysis was executed to gauge the inter-item consistency for the nine variables that used Likert-scale measures namely regulation stringency, environmental regulation, green skills, environmental collaboration, environmental knowledge, environmental strategies, consumer pressure, financial resources and export behavior. In order to execute reliability analysis, a pilot survey was conducted. A sample of 30 respondents were identified for the pilot test (Johanson & Brooks, 2010). Engaging with the respondents at this stage was easier because during the interviews, a good reputation was established with the respondents and environmental consultants.

The preliminary questionnaire was distributed to the respondents that were interviewed and a snowballing technique was employed to identify the respondents of the study through interviewees and environmental consultations. Web survey was used to collect the data. The Cronbach's alpha obtained from the reliability analysis for each of the variable is reported in Table 6.12. For all the variables, the Cronbach's alpha was between 0.820 and 0.930, which is within the cutoff point of 0.7 and above (Nunnally, 1978). Therefore, all the items were deemed reliable and none was deleted.

Table 6.12 : Items reliability-Alpha (α)

Variables	Number of items	Alpha (α)
Regulation stringency	3	0.870
Environmental regulation	3	0.871
Green skills	4	0.924
Environmental collaboration	3	0.930
Environmental knowledge	4	0.913
Environmental strategies	5	0.858
Consumer pressure	2	0.827
Financial resources	3	0.852
Export Behavior	2	0.820

6.4.2 Content and face validity

The reliability analysis provided an assurance that the measurement instrument is able to yield consistent and stable results. The researcher then was able to verify the second issue; the extent the instrument measures the needed measurement. At the beginning stage of questionnaire development, an in-depth literature search was conducted to determine the key dimensions that are required to capture the variables. Next, during the course of the interview, the ability of these dimensions to measure the constructs were further explored and verified through industry participants. Thus, attention was given to the content of the instrument. Once the questionnaire was ready, two sets of experts were identified. The first set of experts consists of six individuals who were the subject matter experts. Among them, two are research supervisors, where one is an expert in the field of EI and the other is an expert in the field of environmental management. The other four are external experts comprising of two environment consultants, two senior chemical industry personnel and an academia with chemical engineering background. The questionnaires were given to the experts for validation within seven days. A face-to-face meeting was arranged with the experts after the seventh day to obtain feedback and for clarification of issues that remain in the black box.

The second set of experts was well versed with questionnaire development knowledge. Two experts from this field assisted in improving the structure, language, scale and wording of the items in the questionnaire. The questionnaires were also given to PhD students embarking on their research in this related area for constructive comments. Engaging the questionnaire with industry personnel during the process of content validation indirectly contributed to face validity. Two main problems solved from the process were the reduction of overlap of content and improvement in the accuracy of the items.

6.5 Population, Sample and Data

6.5.1 Population and Sampling

Three main states (Selangor, Johor and Pulau Pinang) provide substantial coverage to chemical manufacturing firms in Malaysia. For the scope of this study, firms from the Selangor region were considered for the following four reasons:

1. Strong industrial linkages and supporting other industries to move up the value chain: Looking into the complex nature of chemical manufacturing industry and buoyant linkages of its sub-sectors within the industry and with other industries, Selangor proves to be the most vibrant cluster that moved the chemical industry up the value chain. Selangor contributes the lion share of manufacturing production in Malaysia with most of the industries strongly contributing to the total output. Besides the chemical manufacturing industry, automotive, electrical and electronics, construction, food manufacturing and metal industries are also among the high performing industries in Selangor. These industries are highly dependent on the chemical industry, which is a resource-based industry that caters raw and intermediate input to all these industries. The chemical industry cluster in Selangor produces a large volume of specialty chemicals for all this industries and strongly assists all these industries to move up the value chain.

2. Pioneering the chemical industry: The exuberant role played by the chemicals industries could be traced back to the 1980's, when Selangor was identified as the top region for chemical industry cluster under IMP2. Since then, many pioneer chemical manufacturing firms were established in Selangor such as Southern Acids, Henkel, Malaysian Adhesive and Chemicals (MAC), Sissons, ICI, Nylex, CCM Chemicals and others. These firms later became the major chemical players in Malaysia. Moreover, at the initial stage, the chemical firms concentrated on a selected product segments in their respective chemical domain, but now they are manufacturing a more diverse range of products. This is due to the increasing demand for chemical and chemical products by other industries and due to colossal demand from the overseas market.

3. Coverage of both upstream and downstream chemical manufacturing activity and with the highest sales revenue: Prior 1980s, the chemical manufacturing industry focused on the upstream segment, giving greater attention to limited list of petrochemicals. A small scale of other chemical products was produced through high dependence on imported intermediates. This scenario changed with the first innings of the industrial master plan (Malaysia, 1986). The government formulated various strategies to promote the downstream segment of the chemical industry. This in return inflated the number of chemical manufacturing firms in Malaysia, primarily those focusing on the downstream activities. Based on statistic derived from the Companies Commission of Malaysia (SSM) for the year 2013, out of the 573 C&CPM establishments, 48.2% of firms are located in the Selangor cluster. Furthermore, the Selangor cluster accounted for the largest share of chemical manufacturing firm's total sales revenue, which is 35.8% of RM 58,420 billion. Furthermore, the establishment of chemical manufacturing firms follows a certain pattern. The upstream segment of the firms consists both foreign and domestically owned multinational corporations that manufacture mainly basic petrochemicals and oleo-chemicals. In addition, these firms largely fall under the large industry classification. Meanwhile, the downstream segment consists of high value added range of chemical products, which are dominated by domestically owned firms. Moreover, these firms fall under the small and medium industry classification. For all the industry classification (large, small and medium), Selangor exhibits the highest sales revenue, as shown in Figure 6.2. For the large industry classification, the total sales revenue is RM 18082 billion and the Selangor cluster accounts for 33.7%.

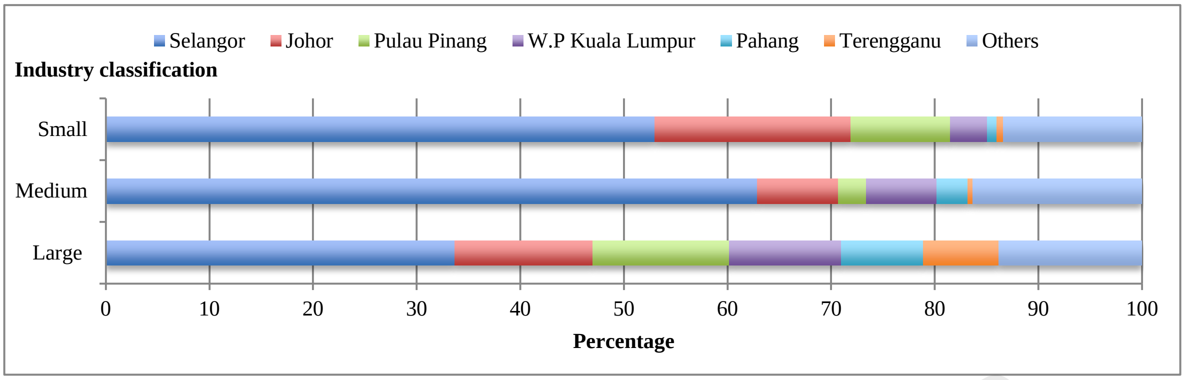

Figure 6.2 : Distribution of total sales revenue of chemical manufacturing firms by state and industry classification
Source: Author's own computation using data obtained from Companies Commission of Malaysia

Amalgamation of a diverse range of chemical sub-sectors: Based on the broad classification, there are ten pertinent sub-sectors within the chemical industry. The list of chemical firms provided by SSM was carefully scrutinized to only select staunch chemical manufacturing firms. From the list 573 firms was finalized and the information provided by SSM on the nature of their business activities was mapped into the ten chemical sub-sectors. Figure 6.3 shows that chemical firms in the Selangor cluster manufacture products related to all the ten sub-sectors. The firms in Selangor dominate the manufacturing activities in the each sub-sector. This shows that the chemical industry in Selangor is a vibrant industry.

To examine the distribution of manufacturing activities within the Selangor cluster, the manufacturing activities within the ten sub-sectors were further divided according to the relevant firm's industry classification (large, medium and small). It is evident that establishments within the sub-sectors consist of large, medium and small business classification (see Figure 6.4).

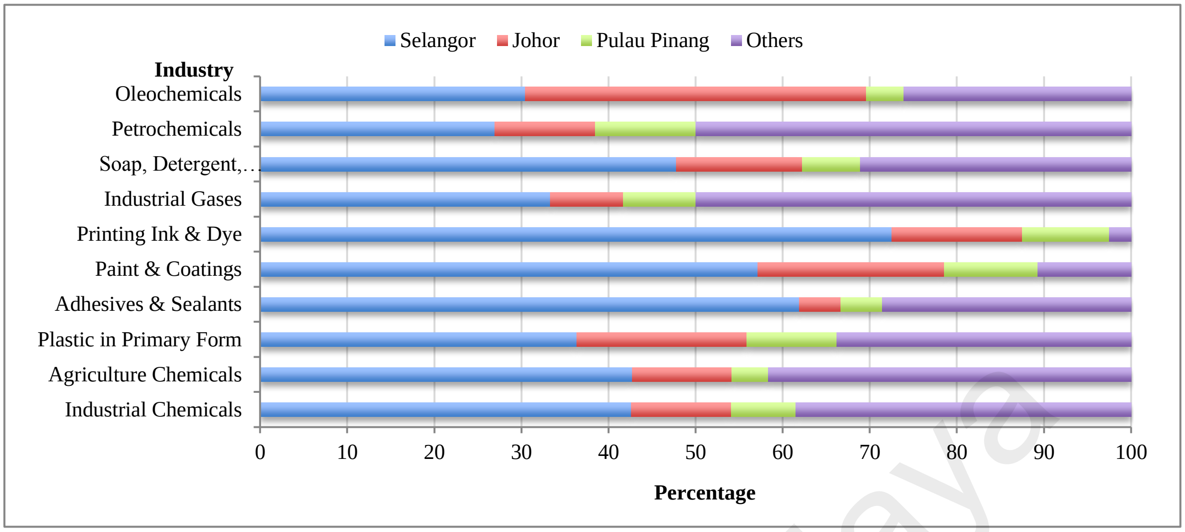

Figure 6.3 : Classification of chemical manufacturing activities into sub-sectors by states
Source: Author's own computation using data obtained from Companies Commission of Malaysia and Federation of Malaysian Manufacturers (FMM) directory

The distribution is logical because establishments from the petrochemicals and oleo-chemicals sub-sector dominate the large business classification, as they are the prime providers of raw material and resources to other sub-sectors within the industry and other industries. Next, establishment that produces intermediate chemicals fall into the large and medium classifications, such as industrial chemicals and plastic in the primary sub-sector. Lastly, establishment for specialty chemical based sub-sectors (agriculture chemicals, industrial gases, adhesive and sealants, paint and coatings, printing ink and dye, soap, detergent and cosmetics) that provide greater downstream value added chemical products are concentrated in the small and medium business classification. Therefore, it can be concluded that the chemical manufacturing firms are strategically distributed within the chemical value chain and contribute to employment and sales revenue for all the business classifications for the state of Selangor.

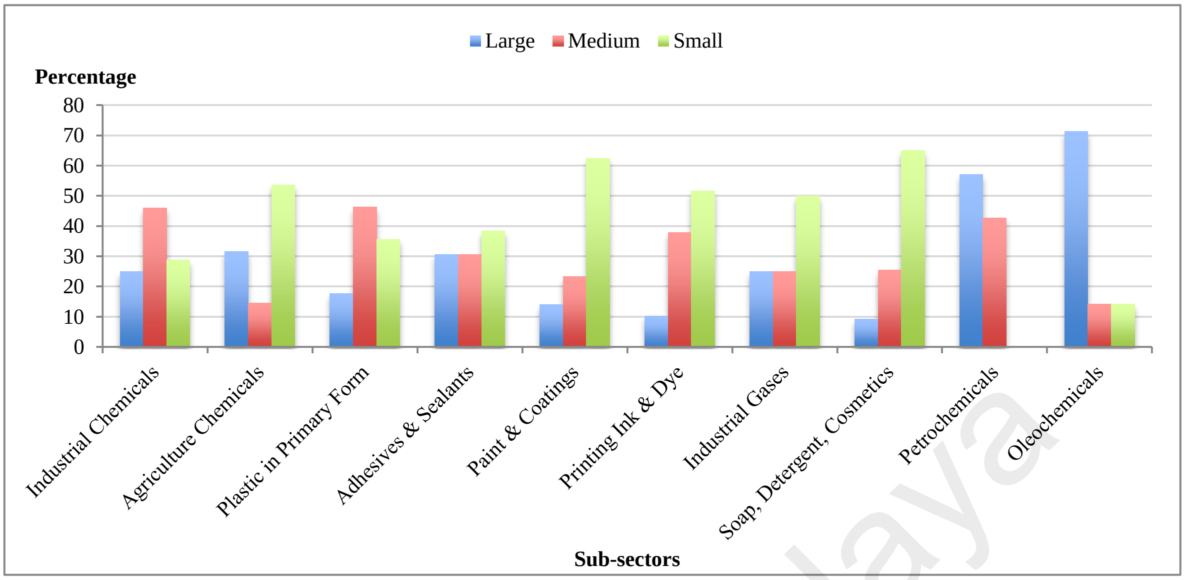

Figure 6.4 : Distribution of Selangor's chemical manufacturing firms according to sub-sectors and within larger, medium and small business classification.
Source: Author's own computation using data obtained from Companies Commission of Malaysia FMM directory

4. Employment creation: The discussion above provided supporting basis to remark that chemical manufacturing firms in Selangor create employment not only within the chemical industry but also other industries due to their strong linkages. The employees in the chemical industry are well-paid, where the manufacture of basic chemicals, fertilizers and nitrogen compound, plastic and synthetic rubber in primary forms was ranked at the second position as the highest average salaries and wages providers (DOSM, 2013).

Besides the dominance reflected by the state of Selangor over Johor and Penang in terms largest share of total revenue (see Figure 3.15) (i.e., both collectively and by business categories - small, medium and large), highest coverage of both upstream and downstream chemical activities and having the biggest number of firms in each 10 chemical clusters. All the three states reflected similar traits from the aspects of foreign capital flow and production of diversified chemical products and strong forward and backward linkages (i.e., within and outside the chemical industry) (see Figure 6.3). The three states had the largest share of total capital investment in approved manufacturing projects and number of manufacturing projects approved by state from 2008-2014 (see Figure 3.7). Therefore, looking into the similarities and also the dominance reflected by the state of Selangor, the selection of sample from the state of Selangor was practical as it effectively represents the total population.

Based on the list obtained from the Companies Commission of Malaysia, there was a total 573 establishment under the chemical manufacturing industry category in Malaysia. Approximately 276 establishments are based in Selangor. The establishments were then categorized into large, medium and small business classifications using the total sales revenue information. Among the 275 firms, 55 firms are classified as large firms, 77 firms as medium and 144 as small. For the purpose of this study, only large and medium sized firms were selected as past studies have showed that larger firms present greater eco-innovative behavior (Przychodzen & Przychodzen, 2015). Therefore, it was a great deal to focus only on the large and medium classifications, which consists of 132 firms. The Web survey questionnaire was emailed to all the 132 C&CPM firms in Selangor. The data collection method is discussed in depth in the following section.

6.5.1.1 Sample Size Test

Prior to the data collection, once the EI Framework was finalized, Gpower software version 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) was used to compute the minimum sample size required to analyze the data using PLS-SEM. Since the conceptual model consists of three sub models, the model with the maximum number of predictors (4 predictors) was used to calculate the sample size. At the power of 0.80 and effect size of 0.15, the minimum number of sample size required to perform the analysis is 85. From the sampling frame of 132 firms, 85 responses were required (65%) to meet the initial requirements before data is analyzed using PLS-SEM.

6.5.2 Data Collection Method

The second stage of data collection is similar to the first stage, where a primary data collection method was employed. A Web based survey questionnaire was used for the data collection purpose. The Web based data collection was assisted by SurveyMonkey-Audience (1999), this online platform is accessed via www.surveymonkey.com/mp/audience. Web survey was primarily selected as it could preferably increase the response rate, as conventional methods such as mail survey is deemed inefficient due to low response rate (Harbaugh, 2002, p. 70).

Web survey managed to tackle the main issue to increase response rate, which is the key informant. The respondents for this study are required to have certain information regarding pollution mitigation in their organizations. This was a challenge as key informants are highly occupied with organizational responsibility (Hunt & Chonko, 1987). Therefore, there are high chances that they might not reply the mailed questionnaire or reject it outright. By using a Web survey this chances was reduced based on several techniques suggested by Kanuk & Berenson (1975) to increase response rate. Techniques such as preliminary notification, follow-up techniques and survey sponsorship were adopted in this study.

Preliminary notification: The list of companies was obtained from the Companies Commission of Malaysia. Contact details of firms were searched form the Federation of Malaysian Manufacturers directory and online databases. The corporations were first contacted through a telephone call and brief information was provided regarding the survey, then the contact details of the specific person in charge of environmental issues in their organization was requested. For firms whose contact details were difficult to obtain, support from personal industrial contacts and linkages was used to acquire their details. The key respondent was contacted through either telephone or email before the web survey was directed to them. This action developed a personal level of commitment between the respondents to answer the survey.

Follow-up: The Web survey allowed a strategic monitoring of the respondents, as it provided the counts of those who have responded, not responded and provided partial responses. Respondents who did not reply within one week, reminder via email was sent, and followed by a phone call if there was no feedback after two weeks. Majority of the respondents answered after the first reminder. Obtaining feedback from the respondents was easy as majority of the sampling frame consists of large and medium sized firms. Most of the large firms are responsible towards the environment and responded quickly to the survey. It was convenient as these large and medium sized firms had a specific department that managed their environmental issues.

Survey sponsorship: To increase the level of confidence and sense of urgency to answer the survey a supporting letter from the Ministry of Energy, Green Technology and Water Malaysia (KeTTHA) was obtained. The information obtained from this this study is used to prepare a policy prescription paper for the ministry this was clearly mentioned in the letter (see Appendix A), which helped ease the process of data collection and to increase response rate. With all the precautions taken to reduce the response bias, the Web survey questionnaire link was emailed to 132 chemical manufacturing firms.

6.6 Final Survey

6.6.1 Questionnaire Format and Administration

The study adopted a web based questionnaire survey; the survey consists of three main sections (see Appendix B). The first section provides a brief description on the purpose of the study and introduction to eco-innovation. This section provided information on how to answer the 7-point Likert-scale questions. The second section (Section A) was structured to collect firm's demographic information, which included among other, the county where their global headquarters is situated, firm ownership, number of employees, export revenue and list of export destinations.

Section C was aimed to collect information related to firm's EI initiatives. The final section was designed to obtain information associated to their EI determinants. In section C, a binary scale was used to collect the information and a Likert scale was used for section D. For the 7-point Likert scale questions, the answers were placed at the scales and respondent were required to choose the answer in the following manner:

1. Circling 1: completely agree with the answer on the left-hand side
2. Circling 2: largely agree with the left-hand side
3. Circling 3: somewhat agree with the left-hand side
4. Circling 4: opinion is indifferent between the two answers
5. Circling 5: somewhat agree with the right-hand side

6. Circling 6: largely agree with the right-hand side
7. Circling 7: completely agree with the answer on the right-hand side

The data collection process continued for approximately four months, within September 2015 and January 2016.

6.6.2 Data Preparation

In the process of data preparation, the data was organized into a spreadsheet, through a series of manual coding and missing values were identified. However, by using the Web survey, this process was not conducted. The Web based database was automatically transported to a spreadsheet. It was then immediately scrutinized for incomplete response and missing values. A total of 102 respondents participated in the Web survey. However, only 97 responses completed. The remaining five responses was rejected as the participants only provided answers for approximately 10 to 20 percent of the questions.

Once the data was cleaned, the information was transferred to SPSS version 22.0. The purpose of this action was to generate exploratory analysis to detect missing values and to ensure data consistency between the amount of data collected from the Web survey and the data transported to the spreadsheet. Next, the missing values were detected and treatment was provided to the missing values using expectation maximization technique. Third, the data was assessed for common method bias and normality. Finally, descriptive statistic was generated and the data was converted to CSV format to support Smart PLS version 3.2.2 for data analysis.

6.6.3 Descriptive Statistics of Firms

This section provides the demographic background of the firms responded to the Web survey (see Table 6.13). The response rate was 73.5% (97 responses /132 views). From the responses, 68% of the firms, their headquarters are based in Malaysia. For rest of the 32% of firms, headquarters of 11% of the respondents is based in Europe, followed by Japan (7.2%) and United States (5.2%). The higher percentage of firms with headquarters in Malaysia could be due to the share of domestic and foreign ownership. Meanwhile, 48.5% of the firms acknowledged that their share of domestic ownership is between 76 – 100%, which implies that almost half of the firms are largely domestically owned. This is further supported by 45.4% of firms indicating that they do not have any share of foreign ownership. However, the fact that there is a potential foreign influence in the firms cannot be discarded as 44.3% of the firms informed that foreign ownership between 26 – 75% does exist. On the other hand, state ownership was apparent in ten firms, and among them 50% indicated a state ownership between 76 – 100%.

For employment figures, two range that dominated the responses are, 100 employees and below and between 151 – 500 employees, where 38.1% or firms falls under the first range and 28.9% in the latter range. Additionally, almost 14 % of the firms denoted that they have employees more than 1000. For the purpose of this study, it was important for the responses to be from exporting firms, as export is one of the EI determinant examined. Based on the feedback, all the responses indicated they are exporting firms as export revenue is generated. Firms with export revenue of less than 10% were among the majority (34%). However, it is important to acknowledge that a large sum of firms have also generated export revenue in the higher range. Where 24% of firms generated export revenue in each of the range, 11 – 25 % and over 50%. Lastly, firms export destination was also explored. Each firm was required to list two of their main export destinations. From the Web survey, 17 countries was identified as main export destinations. The statistical figures showed that the top three export destinations are China (39.2%), Indonesia (36.1%) and Singapore (20.6%). Among the top ten export destinations are dominated by Asian countries. However, 14.4% firms exported to European Union and 9.3% exported to Unites States. Other bottom seven interesting export destinations are India (8.2%), Middle East (7.2%) and South Africa (3.2%). The export destinations are mix of both countries that impose stringent and lax environmental standards.

Table 6.13 : Firms demographic information

Demographic	**Frequency (n=97)**	**Percentage (%)**
Headquarters		
Malaysia	66	68.0%
Europe	11	11.3%
Japan	7	7.2%
United States	5	5.2%
Singapore	2	2.1%
Korea	2	2.1%
Australia	1	1.0%
China	1	1.0%
Taiwan	1	1.0%
U.A.E	1	1.0%
Ownership		
- **Domestic ownership**		
None	16	16.5%
25% or less	5	5.2%
26 – 50%	15	15.5%
51 – 75%	14	14.4%
76 – 100%	47	48.5%
- **Foreign ownership**		
None	44	45.4%
25% or less	10	10.3%
26 – 50%	12	12.4%
51 – 75%	15	15.5%
76 – 100%	16	16.5%
- **State ownership**		
None	87	89.6%
25% or less	3	3.1%
26 – 50%	2	2.1%
51 – 75%	0	0.0%
76 – 100%	5	5.2%

Table 6.13 : Firms demographic information - continue

Demographic	Frequency (n=97)	Percentage (%)
Employment		
< 100	37	38.1%
101 – 150	6	6.2%
151 – 500	28	28.9%
501 – 1,000	12	12.4%
1,001 – 5,000	6	6.2%
> 5,000	8	8.2%
Export revenue		
None	0	0.0%
10% or less	34	35.1%
11 – 25%	24	24.7%
25 – 50%	15	15.5%
Over 50%	24	24.7%
Major export destination		
China	38	39.2%
Indonesia	35	36.1%
Singapore	20	20.6%
Thailand	14	14.4%
European Union (Including UK)	14	14.4%
Japan	13	13.4%
United States	9	9.3%
India	8	8.2%
Korea	8	8.2%
Australia	7	7.2%
Vietnam	6	6.2%
Taiwan	5	5.2%
South Africa	3	3.1%
Myanmar	2	2.1%
Sri Lanka	1	1.0%
Brunei	1	1.0%
*Information not provided	3	3.1%

6.6.4 Descriptive Statistic of Instrument

Table 6.14 outlines the mean, standard deviation, minimum value and maximum value for all the indicators that were analyzed in this study. The descriptive statistics was obtained using Smart PLS version 3.2.2.

Table 6.14 : Descriptive statistics

Construct	Indicator	N	Minimum	Maximum	Mean	Standard deviation
Eco-Process	EP	97	0	6	3.00	1.732
Eco-Organizational	EO	97	0	3	1.66	1.073
Eco-Product	EPR	97	0	3	1.45	1.149
Regulation stringency	RS1	97	1	7	4.10	1.576
	RS2	97	1	7	3.74	1.424
	RS3	97	1	7	4.10	1.550
Environmental regulation	ER1	97	1	7	3.41	1.511
	ER2	97	1	7	3.27	1.477
	ER3	97	1	7	3.19	1.481
Green skills	GS1	97	1	7	4.57	1.617
	GS2	97	1	7	4.61	1.366
	GS3	97	1	7	4.43	1.435
	GS4	97	1	7	3.78	1.581
Environmental collaboration	EC1	97	1	7	4.60	1.493
	EC2	97	1	7	4.15	1.409
	EC3	97	1	7	4.41	1.497
Environmental knowledge	EK1	97	1	7	5.11	1.406
	EK2	97	1	7	5.03	1.418
	EK3	97	1	7	4.81	1.501
	EK4	97	1	7	4.68	1.389
Environmental strategies	ES1	97	1	7	4.55	1.464
	ES2	97	1	7	5.07	1.772
	ES3	97	1	7	4.83	1.310
	ES4	97	1	7	4.81	1.292
	ES5	97	1	7	5.13	1.449
Consumer pressure	CP1	97	1	7	4.27	1.353
	CP2	97	1	7	4.07	1.326
Financial resources	FR1	97	1	7	3.72	1.494
	FR2	97	1	7	3.90	1.520
	FR3	97	1	7	3.79	1.533
Export behavior	EB1	97	1	7	5.10	1.602
	EB2	97	1	7	4.87	1.620

6.6.5 Verifying Data Characteristics

This section describes the methods used to verify the data prior an advanced level of analysis was carried out. The main testing executed to the check for data normality, missing value and common method bias.

6.6.5.1 Missing Data

Missing values were present in the data. Twelve items were detected to have missing values but the percentage was small, between 1 to 2% for each item. To rectify this problem, at the first stage, Little's MCAR test was executed to determine whether the data is missing completely at random. The chi-square statistics value was computed to determine whether data missing completely at random is denoted as Little's MCAR. If the value is not significant, i.e. p. > 0.05, then the null hypothesis is failed to be rejected and the data is said to be missing completely at random. The test results for this study indicated chi-square = 229.852 (df = 283; Sig. = 0.921), which signifies that the data is missing at random. Thus, in the second stage, expectation maximization (EM) technique was used to replace the missing values. EM uses an iterative processing method, where all the variables that are related to the construct are used to forecast the missing values. EM is touted to be a highly accurate and consistent technique for missing data imputation as compared to mean replacement and list-wise techniques (Graham, Hofer, Donaldson, MacKinnon, & Schafer, 1997).

6.6.5.2 Data Normality

The data normality for the study was inspected first by using Shapiro-Wilk's test (p-value > 0.05) (Razali & Wah, 2011). The test indicated that all the variables have a significant value of zero, which implies that the data is not normally distributed. Next, the histograms were visually examined and the skewness and kurtosis was calculated. From the test, the skewness and kurtosis values deviated from zero, providing evidence that the data is not normally distributed. However, a little departure from zero is acceptable with conditions that the values are not extremely large than their standard errors (SE). The skewness and kurtosis values was divided with the SE to obtain the z-values (Cramer, 1998; Doane & Seward, 2011) . More than 85% of the z-values were within the accepted range of ± 1.96 (Cramer & Howitt, 2004) (see Table 6.15). The skewness and kurtosis are still within the recommended range of ± 3 (Klien, 2011). The data is a little skewed and kurtotic but do not extremely deviate from the normality. Nevertheless, the fact that the data is non-normal cannot be disregarded. The non-normal nature of data supported the use PLS-SEM for data analysis.

Table 6.15 : Skewness and Kurtosis

Construct	Indicator	Skewness (S)	z-value (S/SE)	Kurtosis (K)	z-value (K/SE)
Regulation stringency	RS1	-0.237	-0.97	-0.774	-1.60
	RS2	0.162	0.66	-0.424	-0.87
	RS3	-0.107	-0.44	-0.666	-1.37
Environmental regulation	ER1	-0.075	-0.31	-0.892	-1.84
	ER2	0.131	0.53	-0.566	-1.17
	ER3	0.109	0.44	-0.902	-1.86
Green skills	GS1	-0.490	-2.00	-0.566	-1.17
	GS2	-0.340	-1.41	-0.120	-0.25
	GS3	-0.437	-1.78	-0.271	-0.56
	GS4	-0.001	-0.01	-0.930	-1.92
Environmental collaboration	EC1	-0.353	-1.44	-0.385	-0.79
	EC2	0.080	0.33	-0.490	-1.01
	EC3	-0.081	-0.33	-0.621	-1.28
Environmental knowledge	EK1	-0.499	-2.04	-0.533	-1.10
	EK2	-0.607	-2.48	0.160	0.34
	EK3	-0.178	-0.73	-1.091	-2.25
	EK4	-0.441	-1.80	-0.404	-0.83
Environmental strategies	ES1	-0.554	-2.26	-0.384	-0.79
	ES2	-0.826	-3.37	-0.208	-0.43
	ES3	-0.360	-1.47	-0.457	-0.94
	ES4	-0.440	-1.80	-0.199	-0.41
	ES5	-0.653	-2.67	0.036	0.07
Consumer pressure	CP1	-0.344	-1.40	-0.097	-0.20
	CP2	0.191	0.78	-0.447	-0.92
Financial resources	FR1	0.072	0.29	-0.566	-1.17
	FR2	0.038	0.16	-0.481	-0.99
	FR3	-0.117	-0.48	-0.670	-1.38
Export behavior	EB1	-0.843	-3.44	0.087	0.18
	EB2	-0.462		-0.585	-1.21

Note: SE=Standard error, Skewness SE = 0.245, Kurtosis SE = 0.485

6.6.5.3 Common Method Bias

Common methods bias is inherent when self-reported instruments are used to measure more than one construct. The instrument consists of numerous item scales inside a single survey, which is responded by a key informant. This leads to spurious effect not because of the construct being measured but due to the measurement instrument itself (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). For most of the constructs in this study, respondents are required to report their perception in the same survey. The respondent's own view on the environmental protection and preparedness to answer the questionnaire, which is independent from the actual correlation between the constructs that are measured, is likely to cause spurious correlation.

To reduce the comment method bias, items that were adapted were carefully screened during the development stage. The items were worded carefully to avoid social desirability. Items developed from the interview findings was structured as technical items rather than directly wording them based on the outcomes of the interviews. A psychological separation (Podsakoff, MacKenzie, & Podsakoff, 2012) was executed between the items, where the information on the scales was changed when moving from one construct to another and between the items to inhibit previous memory to influence the items being reported. With regard to all the precautions, the potential common method variance may not be entirely removed.

Finally, the widely applied method to assess the common method variance, Harman's (1976) one factor-test was applied once the data was collected. For the purpose of the test, all the variables were subjected to exploratory factor analysis. The aim of this analysis is to assess the results of the un-rotated factor solutions (Andersson & Bateman, 1997; Aulakh

& Gencturk, 2000). A single factor is expected to emerge from the analysis or one main factor that accounts for the majority of the covariance in independent and criterion variables is expected to appear if common method variance is a critical problem (Podsakoff & Organ, 1986). The results extracted seven factors that had Eigen values greater than one. The un-rotated factor structure did not reveal any main factor, with factor 1 accounting for 32.21% of the variance. Therefore, common method variance is not an issue for this questionnaire design.

6.7 Data Analysis Method

6.7.1 Partial Least Squares (PLS)

PLS-SEM was selected primarily due to four reasons. First, the study is exploratory in nature. The determinants of EI are yet to be extensively explored in the context of developing country. Second, once the data was collected, it exhibited non-normality. Next, the sample size was small as targeted group of firms were selected. Lastly, the conceptual model that emerged from the literature and interview findings consists of three sub-models, which required a more robust analysis method. All the issues highlighted are entertained by PLS-SEM (Hair, Hult, Ringle, & Sarstedt, 2014; Peng & Lai, 2012), thus making it the most appropriate method for this research.

6.7.1.1 Construct Type

Multiple items were used to measure the entire latent variable in this research model. All latent variables were reflective. It is essential to determine whether the measurement model is formative or reflective, because misspecification leads to measurement error and affects the validity of the structural model (Jarvis, MacKenzie, & Podsakoff, 2003). For a long time, reflective latent variables are commonly used in the management and social science research (Hair, Hult, Ringle, & Sarstedt, 2014).

Reflective indicators are a set of all possible items that belongs to a related latent variable and are correlated among each other. Therefore, the items of a reflective latent variable could be used interchangeably and an item can be eliminated without changing the meaning of the latent variable, as long as the latent variable achieves adequate reliability. The direction of causality is from the latent variable to the measure. As the indicators for a particular latent variable is highly correlated, a reflective latent variable should be consistent internally. Therefore, it is important to assess this constructs for reliability and validity (Petter, Straub, & Rai, 2007). To assess reliability and validity of the measurement, model certain criterion and test was conducted, which is described in the following section.

6.7.1.2 Measurement Model (Reliability and Validity)

The measurement models represent the properties of the path model that illustrates the relationship between the indicators and the latent variable. In PLS-SEM, this model is commonly referred as the outer model. To ascertain the reliability and validity of the measurement model; the model is assessed for convergent validity and discriminant validity. Factor loading (internal consistency), average variance extracted and composite reliability are used to inspect convergent validity. The discriminant validity is detected using Fornell-Larcker criterion, cross-loadings and HTMT criterion. The following sub-sections explain the standards used to assess the measurement model.

6.7.1.2.1 Internal Consistency

For PLS-SEM, composite reliability (CR) measure is used to evaluate the internal consistency as compared to the traditional method, which is Cronbach's alpha (CA) (Chin, 1998). The strength of internal consistency measure in PLS-SEM is applauded because it ranks the indicator based on their individual reliability, while CA assumes that all the indicators are uniformly reliable. Therefore, CR is more robust as it counts for the dissimilar outer loadings of the indicator variable, making it a more preferable option to measure internal consistency compared to CA (Hair, Hult, Ringle, & Sarstedt, 2014, p. 101). Composite reliability is computed by dividing square of the summation of the factor loadings with the total of square of the summation of the factor loadings plus squared summation of the error variances. CR takes the value between 0 and 1. To indicate sufficient internal consistency or convergence, CR should be 0.7 or greater (Gefen, Straub, & Boudreau, 2000; Segars, 1997).

6.7.1.2.2 Indicator Reliability

Assessment of the indicator reliability allows the researcher to determine the amount of indicator variance that is described by the latent variable. If a construct has higher outer loadings, it reflects that both the item and construct are in common i.e. the item contributes to a large portion of the constructs meaning. According to Chin (1998), the indicators outer loadings should be a minimum of 0.7 and statistically significant. This rule of thumb is used because the communality of an item, which is the square of a standardized indicators' outer loading should be equal to 0.5. This value implies that 50% of the indicator variance is explained by the latent variable. Therefore, to have 50% of indicator variance explained, the outer loadings should be 0.708 ($0.708^2 = 0.50$). On that note, 0.7 is an accepted level as it is adequately close to 0.708. Figure 6.5 is used to clarify this matter further. Values shown on the arrows pointing to X_1, X_2 and X_3 are factor loadings. The square of these values provides the variance extracted (VE), for example, VE for X_1 is $0.725^2 = 0.526$. This value indicates that 52% of variance in X_1 is explained by the latent variable.

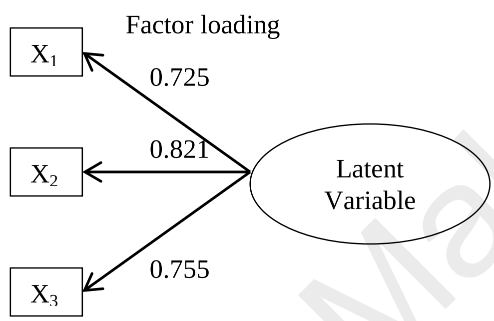

Figure 6.5 : Measurement model example

Weaker loadings are given due attention is social science studies especially when the scales are newly developed. Before an item with outer loading of below 0.7 is eliminated, the change that this elimination causes on composite reliability and construct content validity is observed. If content validity is not affected and the value of composite reliability is not inflated, the deletion of the item can be aborted (Hair et al., 2014). However, it is suggested that items with an outer loadings 0.4 should be removed (Hair, Ringle, & Sarstedt, 2011; Hulland, 1999).

6.7.1.2.3 Convergent Validity

Convergent validity is the degree to which items for a single construct correlates positively with each other. For convergent validity to exist the outer loadings should contribute to a high portion of variance, which is referred as indicator reliability (discussed in the earlier section). Additionally, average variance extracted (AVE), which is commonly identified as the grand mean value of the squared loadings should be more than 0.5 (Hair et al., 2014). AVE is calculated by dividing summation of squared factor loadings with the total of summation of squared factor loadings multiplied with summation of error variances. Values depicted in Figure 6.5, in the previous section are transferred to Table 6.16 to illustrate how AVE is roughly computed. AVE is obtained by dividing total VE with the number of items for the latent variable. Therefore, it can be purported that on average the latent variable explains 59% of the variance of its indicators. Fornell & Larcker (1981) and Bagozzi, Yi, & Phillips (1991) suggested that for sufficient convergent validity to exist, AVE should exceed 0.5.

Table 6.16 : Convergent validity– Average Variance Extracted (AVE)

Item	**Factor Loadings (FL)**	**Variance Extracted (VE) = FL^2**
X_1	0.725	0.526
X_2	0.821	0.674
X_3	0.755	0.570
Total (VE)		1.77
Average Variance Extracted (AVE)		1.77/3=0.59

6.7.1.2.4 Discriminant Validity

Discriminant validity accentuates the uniqueness of a particular latent variable, by indicating its capability to apprehend a phenomenon that is not characterized by other latent variable in the model (Hair et al., 2014). The items of a particular latent variable should constitute to strongly measuring that latent variable and do not unintentionally correlate with other latent variables (Urbach & Ahlemann, 2010). Commonly used method is the PLS to assess that discriminant validity are cross-loadings and Fornell-Larcker’s criterion.

Testing discriminant validity under Fornell-Larcker's criterion requires the comparison among the square root of average variance extracted (AVE) and the correlations coefficients among the latent variables. The square root value of AVE has to be greater than the value of correlation coefficient between the latent variables (Chin, 2010; Fornell & Larcker, 1981). Technically, this method describes that a latent variable should share more variance with its connected indicators that with any other latent variable (Hair et al., 2014).

The next method is cross-loadings; this method is labeled more liberal as compared to Fornell-Larcker's criterion (Hair et al., 2011). Discriminant validity under this method is not a problem, when an indicator's outer loadings on the designated later variable is higher than all of its loadings on the other latent variables in the model (Hair et al., 2014). If this condition is satisfied, then it can be concluded that specific indicators belonging to a latent variable are not substitutable.

Recently, from both the methods, Fornell-Larcker criterion was criticized to exhibit lack of reliability to detect discriminant validity (Henseler, Ringle, & Sarstedt, 2015). Henseler et al. (2015) proposed a new solution and executed a Monte Carlo simulation to prove the command of this method. The suggested approach to assess discriminant validity is built upon multitrait-multimethod matrix, which is referred as heterotrait-monotrait (HTMT) ratio of correlations. Discriminant validity is assessed through two modes as following:

1. Criterion method: The HTMT value should not be greater than 0.85 or 0.90, where each of this HTMT's are denoted as $HTMT_{.85}$ (Klien, 2011) and $HTMT_{.90}$ (Gold, Malhotra, & Segars, 2001).
2. Statistical testing method: Hypothesis testing is executed, where the null (H_0) is HTMT $\geq$ 1 and the alternative (H_1) is HTMT < 1. Discriminant validity is not

established if the confidence interval consists of the value 1. This testing is denoted as $HTMT_{inference}$ (Henseler et al., 2015).

However, even though discriminant validity is assessed using three deferent assessment types, $HTMT_{.85}$ is found to be the most conservative and reliable method. $HTMT_{.85}$ has the capability to detect lack of discriminant validity under circumstances where $HTMT_{.90}$ and $HTMT_{inference}$ has confirmed existence of discriminant validity (Henseler et al., 2015).

6.8 Summary

This chapter exhibited the refined EI framework by taking into account the literature and interview findings. Then by understanding the linkages between the constructs, testable hypotheses were set forth. Additionally, the constructs were also reframed based on the information obtained from the literature and interviews. Furthermore, in this chapter, detailed description is provided on how issues pertaining to measurement, sampling and data collection were handled. Lastly, the data analysis method employed to assess the hypothesis was also discussed, which is further elaborated in the next chapter.

CHAPTER 7 : QUANTITATIVE FINDINGS

7.1 Introduction

This chapter intends to achieve the third and last objective of the study, which is to examine the determinants of eco-innovation in the chemical manufacturing industry. A Partial Least Squares (PLS) technique was used to test the hypothesis of the study using SmartPLS 3.0 software (Ringle, Wende, & Becker, 2015). First, an analysis to ascertain the validity and reliability of the measurement was conducted, followed by the examination of the structural model as suggested by Anderson & Gerbing (1988).

7.2 Assessment of the Measurement Model

This study employed the two phase approach recommended by Anderson & Gerbing (1988). The first phase involves the assessment of the measurement model to confirm the reliability and validity of the model. The criteria used to assess the reliability and validity, as explained in section 6.7.1.2 is summarized in Table 7.1. In this phase, these criteria are used to assess the convergent and discriminant validity.

Table 7.1 : Criteria's to assess the measurement model

	Validity/ Reliability	**Criterion**	**Standards**
1.	Internal Consistency	Composite reliability (CR)	CR > 0.7
2.	Indicator reliability	Indicator loadings	Item's loadings > 0.7, < 0.7, check for CR and AVE before removing the item. > 0.4 advisable to remove.
3.	Convergent validity	AVE	AVE > 0.5
4.	Discriminant validity	Cross Loading Fornell-Larcker HTMT	-All the indicators outer loadings belonging to a specific construct should be the highest as compared to the outer loadings of other indicators on the construct. -Square root AVE of a construct should be greater than the correlation between the construct and other constructs -$HTMT_{.85} < 0.85$

7.2.1 Convergent Validity

Based on Table 7.2, the models outer loadings are all fairly above 0.7, the composite reliabilities and AVE values for all the constructs are above the recommended threshold value, where CR is > 0.7 and AVE is > 0.5. However, one item (FR3) was removed, as the value of its outer loading was 0.532. The removal was supported as it increases the value of CR from 0.860 to 0.942 and the value of AVE from 0.685 to 0.890. The item did not impose any constrain on the meaning of the construct as all the items for the constructs belong to the same dimension i.e. financial barriers. In totality, the assessment of the measurement models loadings, composite reliability, AVE provide adequate evident to establish convergent validity. This indicated that the measures of constructs that were determined through the literature and interview findings are in fact related.

Table 7.2 : Convergent validity of measurement model

Construct	Item	Loadings	AVE[a]	CR[b]
Eco-Innovation	EP	0.800	0.654	0.850
	EO	0.806		
	EPR	0.820		
Regulation stringency	RS1	0.813	0.683	0.865
	RS2	0.728		
	RS3	0.926		
Environmental regulation	ER1	0.948	0.775	0.911
	ER2	0.946		
	ER3	0.730		
Green skills	GS1	0.776	0.698	0.902
	GS2	0.922		
	GS3	0.868		
	GS4	0.766		
Environmental collaboration	EC1	0.860	0.723	0.887
	EC2	0.802		
	EC3	0.887		

Table 7.2 : Convergent validity of measurement model - continue

Construct	Item	Loadings	AVE[a]	CR[b]
Environmental knowledge	EK1	0.864	0.760	0.927
	EK2	0.891		
	EK3	0.901		
	EK4	0.828		
Environmental strategies	ES1	0.729	0.639	0.898
	ES2	0.779		
	ES3	0.877		
	ES4	0.860		
	ES5	0.740		
Consumer pressure	CP1	0.894	0.799	0.888
	CP2	0.894		
Financial resources	FR1	0.923	0.890	0.942
	FR2	0.959		
Export behavior	EB1	0.953	0.895	0.945
	EB2	0.939		

[a]AVE = (summation of squared factor loadings)/(summation of squared factor loadings) (summation of error variances)
[b]Composite reliability = (square of the summation of the factor loadings)/[(square of the summation of the factor loadings) + (square of the summation of the error variances)]

7.2.2 Discriminant Validity

For discriminant validity, all three criteria suggested by the researcher were used to prove a solid grounding of the measurement model. The first criterion is Fornell-Larcker as shown in Table 7.3. The values that represent the square root of AVE are on the diagonal (bolded), while the correlation between the construct are placed right below the square root of the AVE. From the table it is evident that the discriminant validity criteria are met, where the square root of every construct AVE is larger than the construct correlation with other constructs.

Table 7.3 : Fornell-Lacker criterion

	CP	EB	EC	EI	EK	ER	ES	FR	GS	RS
CP	**0.894**									
EB	0.319	**0.946**								
EC	0.305	0.490	**0.851**							
EI	0.369	0.101	0.209	**0.809**						
EK	0.401	0.714	0.705	0.231	**0.872**					
ER	0.351	-0.115	0.002	0.393	0.000	**0.880**				
ES	0.510	0.660	0.623	0.322	0.688	0.127	**0.799**			
FR	0.072	-0.026	0.054	0.097	0.105	0.356	0.056	**0.944**		
GS	0.496	0.594	0.694	0.311	0.714	0.088	0.708	0.013	**0.836**	
RS	0.215	0.180	0.112	0.156	0.245	0.432	0.234	0.142	0.191	**0.826**

Note: The bolded values on the diagonals are the square roots of AVE and values below them are the correlations among constructs

Next, sufficient discriminant validity in the measurement model was further confirmed trough the observation of cross loadings (see Table 7.4). From the table, all the outer loadings that belong to a designated construct (values in bold) exhibit higher value as compared to the outer loadings of other constructs directed towards that particular construct.

Table 7.4 : Cross loadings

	CP	EB	EC	EK	EI	ER	ES	FR	GS	RS
CP1	**0.894**	0.235	0.260	0.363	0.250	0.286	0.456	0.017	0.458	0.119
CP2	**0.894**	0.334	0.285	0.353	0.409	0.342	0.457	0.111	0.429	0.266
EB1	0.303	**0.953**	0.509	0.684	0.060	-0.082	0.663	-0.024	0.589	0.215
EB2	0.299	**0.939**	0.412	0.668	0.137	-0.140	0.581	-0.025	0.532	0.120
EC1	0.177	0.452	**0.860**	0.633	0.167	-0.042	0.448	0.047	0.583	0.158
EC2	0.326	0.310	**0.802**	0.468	0.127	0.113	0.476	0.013	0.481	0.179

Table 7.4 : Cross loadings - continue

	CP	EB	EC	EK	EI	ER	ES	FR	GS	RS
EC3	0.278	0.470	**0.887**	0.676	0.226	-0.043	0.639	0.070	0.681	-0.014
EK1	0.255	0.620	0.687	**0.864**	0.133	-0.022	0.598	0.079	0.634	0.133
EK2	0.356	0.702	0.582	**0.891**	0.200	0.006	0.634	0.150	0.639	0.284
EK3	0.354	0.608	0.547	**0.901**	0.288	0.024	0.592	0.076	0.587	0.263
EK4	0.433	0.555	0.637	**0.828**	0.191	-0.008	0.572	0.058	0.624	0.175
EO	0.251	0.072	0.176	0.179	**0.800**	0.350	0.209	0.092	0.193	0.144
EP	0.226	0.003	0.081	0.067	**0.807**	0.293	0.237	0.026	0.181	0.182
EPR	0.399	0.155	0.236	0.293	**0.819**	0.309	0.326	0.109	0.361	0.065
ER1	0.370	-0.109	0.022	0.005	0.384	**0.948**	0.117	0.271	0.108	0.431
ER2	0.276	-0.134	-0.020	-0.035	0.398	**0.946**	0.127	0.313	0.061	0.423
ER3	0.294	-0.040	0.008	0.054	0.216	**0.730**	0.086	0.423	0.062	0.252
ES1	0.336	0.386	0.563	0.531	0.172	0.094	**0.729**	0.146	0.528	0.089
ES2	0.355	0.595	0.425	0.528	0.288	0.057	**0.779**	0.056	0.528	0.191
ES3	0.411	0.552	0.539	0.540	0.305	0.055	**0.877**	-0.057	0.620	0.216
ES4	0.467	0.611	0.577	0.662	0.221	0.036	**0.860**	0.032	0.666	0.217
ES5	0.465	0.469	0.384	0.479	0.298	0.291	**0.740**	0.072	0.468	0.209
FR1	0.045	-0.014	0.068	0.117	0.074	0.286	0.039	**0.924**	0.025	0.152
FR2	0.084	-0.032	0.039	0.087	0.104	0.374	0.063	**0.963**	0.004	0.121
GS1	0.483	0.517	0.558	0.552	0.283	0.083	0.563	0.043	**0.776**	0.269
GS2	0.498	0.606	0.680	0.733	0.312	0.041	0.694	-0.087	**0.922**	0.221
GS3	0.348	0.427	0.583	0.566	0.231	0.125	0.630	0.081	**0.868**	0.095
GS4	0.306	0.416	0.473	0.505	0.199	0.048	0.445	0.031	**0.766**	0.029
RS1	0.201	0.194	0.048	0.132	0.102	0.314	0.258	0.088	0.133	**0.813**
RS2	0.136	0.079	0.034	0.100	0.018	0.366	0.159	0.172	0.108	**0.729**
RS3	0.186	0.143	0.134	0.275	0.169	0.417	0.178	0.140	0.194	**0.926**

Note: The bolded values are outer loading that belongs to the constructs that they are under.

The final benchmark used to assess discriminant validity is the HTMT criterion (see Table 7.5). For the purpose of this study, $HTMT_{.85}$ is selected as compared to $HTMT_{.90}$ and $HTMT_{inference}$ as it is more reliable and consistent in assessing discriminant validity (Henseler et al., 2015). HTMT ratios are < 0.85, which indicate sufficient discriminant validity. Therefore, a thorough assessment of discriminant validity using all the three criteria provides the assurance that the constructs are truly different from each other by empirical standards.

Table 7.5 : Heterotrait –Monotrait Ratio (HTMT)

	CP	**EB**	**EC**	**EI**	**EK**	**ER**	**ES**	**FR**	**GS**	**RS**
CP										
EB	0.392									
EC	0.393	0.566								
EI	0.486	0.139	0.256							
EK	0.490	0.802	0.815	0.276						
ER	0.445	0.126	0.092	0.476	0.055					
ES	0.637	0.750	0.735	0.400	0.784	0.154				
FR	0.085	0.028	0.067	0.113	0.121	0.431	0.105			
GS	0.613	0.676	0.814	0.377	0.807	0.112	0.813	0.096		
RS	0.260	0.186	0.182	0.175	0.231	0.495	0.271	0.187	0.196	

Note: HTMT ratios should be smaller than 0.85 ($HTMT_{.85}$ < 0.85)

7.3 Assessment of the Structural Model

Assessing the measurement model completes the first phase, and the second phase involves the examining of the structural model. Assessment of the measurement model will provide the main findings of the study. In this stage, the model is assed for collinearity issues. Then the hypothesized relationships are tested followed by valuation of R^2, effect size (f^2), and predictive relevance (Q^2). Collinearity is determined by computing the variance-inflated factor (VIF), where VIF < 5 indicates absence of collinearity (Hair et al., 2014). Thus, with regard to Table 7.6, from the very beginning the analysis discarded the prevalence of collinearity as all the VIF values were less than 5.

Table 7.6 : Variance inflation factor (VIF)

	EI	ES	GS
CP	-	1.333	-
EB	-	1.577	-
EC	-	1.972	1.991
EK	-	-	1.991
ER	1.382	-	-
ES	1.059	-	-
FR	1.146	-	-
GS	-	2.674	-
RS	1.282	-	-

Note: VIF < 5 indicate absence of collinearity

7.3.1 Direct Effect

To assess the significance of the path coefficients (see Table 7.7), t-statistic was generated through a bootstrapping procedure, with 5000 resamples to assess the hypothesis. First, the two determinants of green skills in the recourse model were examined. Both environmental knowledge ($\beta = 0.446$, $p < 0.01$) and environmental collaboration ($\beta = 0.379$, $p < 0.01$) were positively related to green skills explaining 58.1 %of the variance in green skills. Next, the all antecedence of the strategy model (model two) was assessed. The model consists of four antecedences: environmental collaboration (β = 0. 221, $p < 0.01$), green skills ($\beta = 0.250$, $p < 0.01$), consumer pressure (β = 0.0.212, $p < 0.01$) and export behavior ($\beta = 0.336$, $p < 0.01$), which exhibited a positive relationship with environmental strategies explaining 65.4% of the variance in environmental strategies. Thus, the hypothesis of both the models, H_1, H_2, H_{3a}, H_4, H_5 and H_6 were supported. The R^2 values for both the models were above the substantial model threshold of 0.26 as suggested by Cohen (1988). Therefore, indicating both the models has a relatively strong predictive accuracy. The last model is eco-innovation model, which is the focus of this study. In this model two drivers were found to positively effect EI namely, environmental regulation ($\beta = 0.41$, $p < 0.01$) and environmental strategy ($\beta = 0.292$, $p < 0.01$). Meanwhile, two other factors were not significantly related to EI. Hence, for this model, hypothesis H_8 and H_9 was supported and H_7 and H_{10} were not supported. The driver that has positive relationship explained 23.7% of variance in EI. The R^2 value for this model is above 0.13, indicating a moderate model (Cohen, 1988).

Next, to ascertain the effect size (f^2), the change in R^2 was observed by omitting a specific construct from the model. This provided an indication whether the omitted predictor construct has an essential impact on the endogenous construct (Hair et al., 2014). It is important to determine the effect size, because P value only reveals whether an effect size exists, but do not inform the size of the particular effect. Therefore, while interpreting and reporting research, the substantive significance (f^2) and statistical significance (P value) should be reported to reflect the strength of the model (Sullivan & Feinn, 2012). The f^2 values reported in Table 7.3 are assessed based on the guidelines provided by (Cohen, 1988), in which 0.35, 0.15 and 0.02, respectively, indicate large, medium and small effects. Substantive impact was observed for all the eight supported hypothesized relationships with four medium effects and four small effects.

Additionally, besides assessing the magnitude of R^2 to gauge the predictive accuracy, steps we also taken to measure the model's predictive relevance (Q^2). Generally predictive relevance estimates the extent to which a predictive accuracy is relevant. The Q^2 values in Table 7.3 are obtained by using blindfolding procedure, which is basically a sample reuse technique. Through this technique, certain portion of the data matrix is omitted and the model estimates are used to forecast the omitted portion (Chin, 1998; Henseler, Ringle, & Sinkovics, 2009). Blindfolding procedures are only suitable for reflective measurement models, with either single of multiple items (Hair et al., 2014). The predictive relevance is sufficient when $Q^2 > 0$ and lack predictive relevance is indicated when $Q^2 < 0$ (Fornell & Cha, 1994). All the three Q^2 figures in the table were above zero signifying sufficient predictive relevance. Following an alternative criteria proposed by Hair et al., (2014), in which small (0.02), medium (0.15) or large (0.35) predictive relevance are indicated. For this study model 1 ($Q^2 = 0.397$) and 2 ($Q^2 = 3.96$) indicated high predictive relevance, while model 3 ($Q^2 = 0.127$) indicated medium predictive relevance.

Table 7.7 : Results of the Structural Model Analysis

Hypothesis		**Std. Beta**	**Std. Error**	**T-Value**	**Decision**	**R^2**	**f^2**	**Q^2**
Model 1								
H_1	EK-> GS	0.446	0.096	4.628**	Supported	0.581	0.239	0.397
H_2	EC-> GS	0.379	0.092	4.107**	Supported		0.172	
Model 2								
H_{3a}	EC-> ES	0.221	0.092	2.404**	Supported	0.654	0.069	0.396
H_4	GS-> ES	0.250	0.087	2.885**	Supported		0.066	
H_5	CP-> ES	0.212	0.069	3.053**	Supported		0.095	
H_6	EB-> ES	0.336	0.088	3.829**	Supported		0.201	
Model 3								
H_7	FR -> EI	-0.054	0.096	0.562	Not Supported	0.237	0.003	0.127
H_8	ER -> EI	0.410	0.100	4.121**	Supported		0.160	
H_9	ES -> EI	0.292	0.088	3.304**	Supported		0.106	
H_{10}	RS -> EI	-0.082	0.133	0.621	Not Supported		0.007	

**p<0.01

7.3.2 Indirect Effect

Indirect effect analysis was performed based on the new paradigm as suggested by Hayes (2009) to challenge the four step approach suggested by Baron & Kenny (1986), which is irrelevant and lack of substance. Besides Hayes other scholarly studies have also claimed that the four-step approach is unnecessary as significant indirect effect could transpire with the absence of total and direct effect (Rucker, Preacher, Tormala, & Petty, 2011). Hair et al., (2014) advocated that researcher should follow recommendations made by Preacher & Hayes (2004, 2008) and bootstrap the sampling distribution of the indirect effect.

Therefore, the result of the study is reported according to those recommendations (see Table 7.8), where to confirm the indirect effect is significant. The coefficient should not straddle a zero between the lower and upper limit of 95% bootstrap confidence interval. The indirect effect hypothesized in model 2 and 3, H_{1b} (β = 0.112, 95% Boot CI: [LL = 0.027, UL = 0.203]), H_{3b} (β = 0.092, 95% Boot CI: [LL = 0.019, UL = 0.172]), H_{4b} (β = 0.073, 95% Boot CI: [LL = 0.010, UL = 0.141]), H_{5b} (β = 0.062, 95% Boot CI: [LL = 0.011, UL = 0.118]), H_{6b} (β = 0.098, 95% Boot CI: [LL = 0.024, UL = 0.169]) are statistically significant. Since, the indirect effects do not straddle a zero in between the upper and lower limit of 95% bootstrap confidence interval.

Table 7.8 : Indirect analysis results

Hypothesis		**Indirect effect (β)**	**Std. Error**	**T value**	**Bootstrap 95% confidence interval (BC^a)**		**Decision**
					Lower	Upper	
Model 2							
$H1_b$	EK -> ES	0.112	0.046	2.445**	0.027	0.203	Significant
Model 3							
$H3_b$	EC -> EI	0.092	0.041	2.259*	0.019	0.172	Significant
$H4_b$	GS -> EI	0.073	0.035	2.113*	0.010	0.141	Significant
$H5_b$	CP -> EI	0.062	0.029	2.175*	0.011	0.118	Significant
$H6_b$	EB -> EI	0.098	0.038	2.612*	0.024	0.169	Significant

**p<0.01, p*<0.05, BC^a = bias corrected

7.4 Importance-Performance Matrix Analysis (IPMA)

Important-performance matrix (IPMA) analysis was expedited in order to advance the PLS-SEM findings of the present study. The foundation of IPMA is based on the estimates of the path model relationships and average value of the latent variable. The analysis involves a faceoff between the total effects of the estimates (importance) and the average value of the latent variable score (performance). The performance score is rescaled, where 100 denotes the highest performance and 0 otherwise (Hair et al., 2014). Meanwhile, the important sores is an index, which explicate the variance of the endogenous target construct (Völckner, Sattler, Hennig-Thurau, & Ringle, 2010). The total effect accounts for all the direct and indirect relationships that exist between the two constructs (Hair et al., 2014).

In this study, the IPMA map was generated for each of the model. For model 1, the total effects and the index values are presented in Table 7.9. These statistics were later used to generate the IPMA map (see Figure 7.1). From the map, it is observed that both the performance and importance for environmental knowledge is higher compared to environmental collaboration in determining firms green skills. Therefore, it is advisable that the firms place greater attention to environmental knowledge accumulation activities to develop green skills among employees.

Table 7.9 : IPMA -Total effects and index values (Model 1)

Latent Variable	Total effect of the latent variable Green Skills (Importance)	Index Values (Performance)
EC	0.376	56.571
EK	0.448	65.223

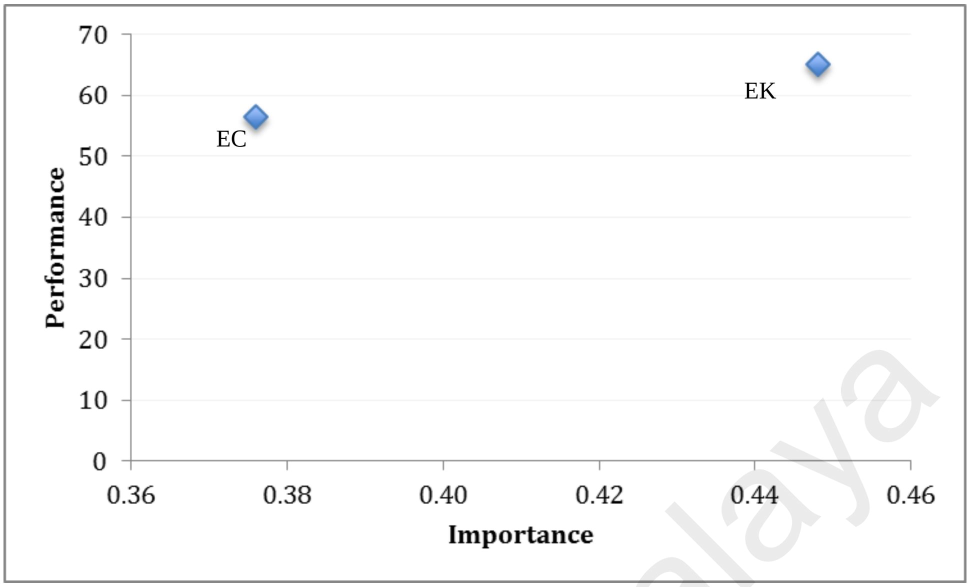

Figure 7.1 : Model 1 IPMA map

Next, the strategy model, environmental collaboration and export behavior exhibited high importance with environmental collaboration heading it (see Table 7.10 and Figure 7.2). However, at the performance front, export behavior portrayed higher performance comparative to the environmental collaboration. Both of these constructs could be given extra attention by the firms. Resources and technical assistance provided through environmental collaboration to formulate environmental strategies is within the control of the firms, thus firms are able to direct the drivers to best suit the interest of the firms. Export behavior, on the other hand, exhibited high performance but is an external influence on the firm's environmental strategy. Firms have to engage constantly with the changes in the export market and foreign counterparts to infuse the changes into the environmental strategies. Attention should also be given to green skills as it differs marginally from export behavior in terms of importance.

Table 7.10 : IPMA -Total effects and index values (Model 2**)**

Latent Variable	Total effect of the latent variable Environmental strategies (Importance)	Index Values (Performance)
CP	0.203	52.894
EB	0.253	66.630
EC	0.289	56.571
EK	0.103	65.223
GS	0.230	56.711

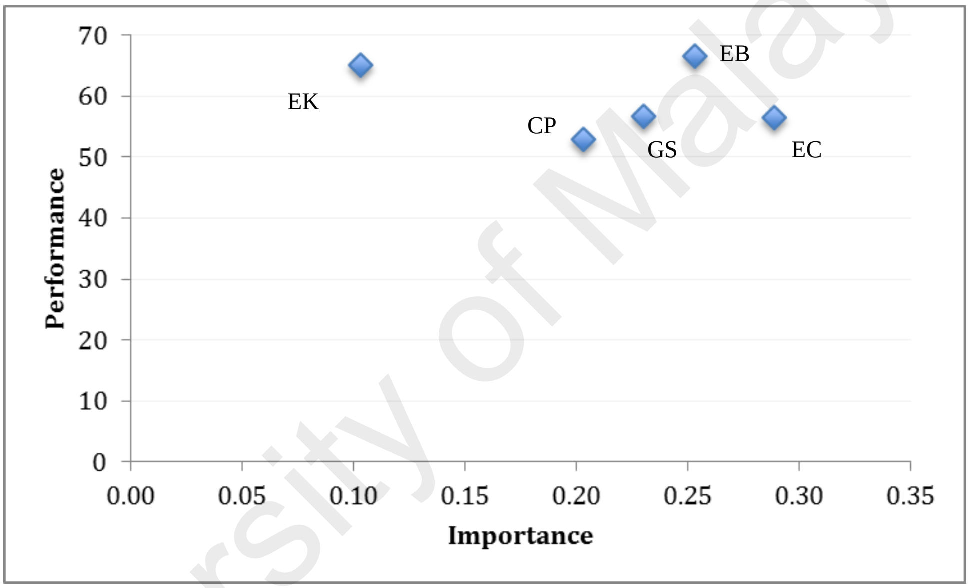

Figure 7.2 : Model 2 IPMA map

Model 3 is the final model that was analyzed through the IPMA (see Table 7.11 and Figure 7.3). Among the factors mapped for this model, environmental strategies and environmental regulation scored high for importance and performance in stimulating EI. In terms of importance, environmental regulation was leading comparative to environmental strategies and vice versa for performance. Firms need to give due consideration towards these two factors. Environmental strategies provide the initial impetus for firms to eco-innovate, while environmental strategies congregate firm’s resources and capabilities to eco-innovate. Extra attention toward environmental strategies can extremely boost firm's EI initiatives because it requires the invigoration of the other factors shown in the map. This in return increases the indirect impact that these factors impose on EI.

Table 7.11 : IPMA -Total effects and index values (Model 3)

Latent Variable	Total effect of the latent variable Eco-Innovation (Importance)	Index Values (Performance)
CP	0.052	52.894
EB	0.065	66.630
EC	0.074	56.571
EK	0.027	65.223
ER	0.309	38.503
ES	0.257	64.588
GS	0.059	56.711

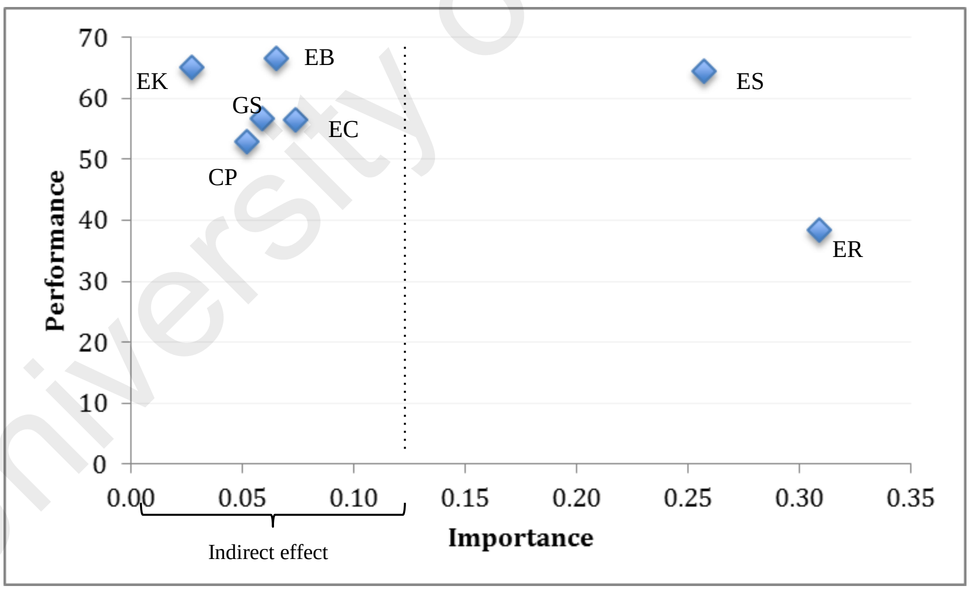

Figure 7.3 : Model 3 IPMA map

7.5 Summary

The first phase of analysis involved evaluation of five criteria's namely: composite reliability, outer loadings, AVE, cross loadings, HTMT ratio and Fornell-Larcker to assess the validity and reliability measurement model. And all the criteria's confirmed the validity and reliability of the measurement model. On the other hand, the second phase of the analysis involved the assessment of the structural model, which is to test the direct and indirect relationships hypothesized in the study. For Model 1, both the direct relationship for environmental knowledge and environmental collaboration with green skills was supported. Similarly, for Model 2, all the hypothesized direct relationship for environmental collaboration, green skills, and consumer pressure and export behavior with environmental strategies was also confirmed. However, for Model 3, out of the four hypothesized direct relationship only two were supported, the environmental regulation and environmental strategies with EI. Meanwhile, direct relationship of financial resources and regulation stringency with EI was not supported.

Next, for indirect hypothesized relationships, all indirect effects were significant. The environmental knowledge influences environmental strategies through green skills. The environmental collaboration, green skills, and consumer pressure and export behavior influence EI through environmental strategies. Testing of the hypothesis was followed by Important-performance matrix (IPMA) analysis to gauge the imperative EI determinants. For Model 1, environmental knowledge was found to exert greater performance and importance in determining firms green skills as compared to environmental collaboration. IPMA for Model 2 indicated that export behavior and environmental collaboration were imperative determinants for shaping firms environmental strategies. Where the prior was found to be superior in terms of performance, and the later in terms of importance in influencing environmental strategies. In totality, IPMA for Model 3, which is in fact the EI framework, showed that environmental strategies and environmental regulation has considerable impact of EI. Impact wise, environmental strategies exerted higher performance, while environmental regulation exerted greater importance. Since IPMA takes into consideration both direct and indirect effect, it was found that among all the determinants that exhibited indirect effect on EI, environmental collaboration has higher importance and export behavior has higher performance on EI.

CHAPTER 8 : IMPLICATIONS AND LIMITATIONS

8.1 Introduction

Since EI has the capability to reduce emissions and catalyze green economic growth, under the United Nation Environmental Programme (UNEP), EI was identified as the backbone to achieve the state of 'green utopia'- i.e. ideal state of green economy (UNEP, 2008, p. 35). Prior an economy embarks on a journey to achieve the state of green utopia through effective environmental policies, the understanding of the spectrum of EI in that economy is imperative. Understanding the spectrum of EI begins with assessing the state of EI and exploring the sustainable manufacturing concepts and practices that are embraced by the industries. Next, considering the fact that the level of EI differs across sectors (Montalvo, 2008), and EI is the outcome of complex systems (Grubb, 2004), there is a need to explore the sector specific EI determinants in order to develop a sector specific EI framework. Then, this framework should be tested empirically to determine the imperative EI determinants.

Therefore, by responding to the call from the literature, and by considering Malaysia's future plans to promote EI and EI driven green economic growth, this study employed both qualitative and quantitative approach to understand the spectrum of EI in the chemical manufacturing industry (i.e., assess the state of EI (objective 1), explore the EI framework (Objective 2) and examine the EI determinants (objective 3)). Aforementioned, this information is essential for policy makers to plan better innovation oriented-environmental policies in Malaysia, which is currently lacking. Moreover, currently the initiatives to EI in Malaysia is segmented between several ministries, and Malaysia is in the stage of providing more liberty to the firms to solve their environmental issues. In that case, knowledge pertaining to EI becomes even more critical.

This chapter recapitulates the key findings of the study. The key findings are presented according to the objectives outlined for the purpose of this study. Furthermore, wherever necessary, the findings are supplemented with policy and managerial implications. There is also a separate section in the chapter that highlights policy, managerial and theoretical implications in further detail. Finally, the chapter concludes with information pertaining to limitations of the study and scope for future research direction.

8.2 Recapitulation of Key Findings

In this section, both the qualitative and quantitative findings are merged to provide a more holistic perspective to solve environmental problems through EI. The recapitulation of the main findings is according to the research objectives and necessary policy suggestions are included.

8.2.1 State of Eco-Innovation (Objective 1)

Based on the statistics and the interviews, it is inferred that for process EI, there is a large fraction of firms that are still depending on end-of-pipe solution. They directly adopt these technologies to comply with environmental requirements set by the authorities to treat pollutants before it is released into the atmosphere. The nature of environmental regulation in Malaysia has long emphasized enforcement and monitoring to treat pollution, which could be the reason for firms to be comfortable with end-of-pipe solutions. This effort is definitely not sufficient to promote long-term sustainable manufacturing. Firms have to move away from process EIs that are merely treating hazardous chemical before releasing them to the environment to process EIs that prevent and manage the usage of such chemicals. The Ministry of Natural Resource and Environment (MNRE) intends to promote the cradle-to-cradle principle among firms (Ismail & Julaidi, 2015). For this principle to work, initiatives to push firms to adopt more advanced pollution mitigation concepts and process EIs are required. Furthermore, from all the three types of EI, the commercialization of process EIs has the highest economic value, as the profit margin is greater. However, looking at the current scenario, the adoption of process EIs is greater than creation. Policies that encourage homegrown process EIs are urgently required to harness the benefits to be competent in green technology. It is interesting to know that firms are introducing green energy technologies (EP6), however, the figures are not encouraging.

The findings revealed that the level of organizational EI that firms have acquired so far has advanced from just treating environmental problems to managing them. Firms have understood that in order for them to increase their environmental performance, it requires collective organizational involvement (Brunnermeier & Cohen, 2003) and strong relationship between each type of EIs, to holistically tackle environmental problems (Cheng et al., 2014). Therefore, firms have adopted a systematic environmental management approach, where they are using organizational EIs to integrate every environmental initiative to increase their environmental performance. This integration allows them to execute their environmental strategies more effectively, as the implementation and monitoring of these strategies becomes much easier. Increasing pressure from trading partners to comply with stringent chemical standards is found to be the main reason for firms to adopt or create these organizational EI. For organizational EI, there is a greater level of creation as compared to process EI. Firms are seen designing their own unique ways to manage their resources, material and stakeholders, which either directly or indirectly contributes to their environmental performance. Besides working on increasing their eco-efficiency through systematic environmental management organizational EIs, firms are using these organizational EIs to slowly embrace life cycle-thinking approach, as they are taking serious efforts to greening their supply chain. The lifecycle thinking approach that firms are embracing is highly related to the cradle-to cradle principles that MNRE is planning to promote. Therefore, policies that assist the firms in their transition from organizational EIs to manage their environmental issues, and to organizational EIs that extends their environmental responsibility by greening their entire supply chain is currently required. As firms have made the effort, policies could intensify this effort by providing them proper guidance and knowledge.

For the period of 2010-2015, almost 50% of the firms ventured into product EI and consumed the largest share of their R&D allocations compared to process and organizational EI. Besides improving the energy efficiency and lower emission feature of the products, firms are actively changing other specific features (i.e., chemical related) of the products as well. This is entirely due to the product lifecycle approach that firms have currently employed. Firms are also highly creating their own green products to secure their market share and explore the wide green product market to remain competitive. The findings suggested that firms are ripping huge benefits by greening their products because Malaysian chemical products are highly recognized for its quality and compliance with environmental standards. Understanding the reputation that Malaysian chemical products have gained internationally, and the chemical industry being the second largest export sector of the country, Malaysia has a comparative advantage by seriously venturing into green chemical products. Issues that require immediate attention by policy makers are patent and institutional support. As there is an influx of green products, the authorities have to increase the sophistication of the patenting system (i.e., specifically for EIs), which is currently lacking. Overwhelming institutional support is required as firms are largely investing into product EI R&Ds, which takes into account advanced manufacturing approach such as product lifecycle. Thus, for now, research labs and training centers must be at least equipped with facilities that churn research and human resource according to product lifecycle principles and practices.

Foreign influence within the firms was seen as extremely important aspect to promote EI. Firms with foreign headquarters location and ownership exhibited greater introduction of EI as compared to firms with domestic headquarters location and ownership. Additionally, these firms largely introduced process related EIs, which are imperative to reduce environmental harm throughout the production process. Similarly, domestically inclined firms (i.e., ownership and headquarters) are also introducing process related EIs and sometimes at a marginally higher percentage than those with foreign headquarters and ownership. However, these process EIs are the basic types of EIs that are required to mitigate pollution (i.e., environmental monitoring, noise and vibration control technologies). Besides process EI, domestic centred firms, even though not as high as foreign centred firms, recorded high percentage of introduction for product EI category. When it comes to firms with state ownership, they registered higher percentage of EI introduction as compared to firms with domestic ownership, while the type of EIs introduced by both were the same (i.e., in process and product EI category). In terms of the intensity of EI, both the foreign centred and domestic centred firms were net adopters with domestic centred firms taking the lead. The level of adoption for both the foreign and domestic centred firms were from the process and organizational EI category. While for EI creation the foreign centred firms were dominating especially in the product EI category.

8.2.2 Eco-Innovation Framework and Determinants (Objective 2 & 3)

All the nine EI drivers explored in this study exhibited their relevance and importance for firms to eco-innovate. The case study findings indicated that there were three sub models within the EI framework, which strategically linked these nine EI drivers. The framework clearly depicted that for radical EI to transpire; government has to embark on policy measures from three policy interventions simultaneously. The first policy intervention is in terms of green skills (Model 1) (see Figure 6.1). According to firms, employees have to be well equipped with all the technical and non-technical environmental knowledge that flow into the firms and are the backbone for the firms to eco-innovate. Greening their employees has been among the main priorities for the firms and this is mainly achieved through provision of trainings and awareness.

Environmental knowledge is accumulated primarily from their group, exhibitions, research, and suppliers while information is obtained via collaborations. Consequently, environmental knowledge is used to design the training modules and provide continuous environmental awareness. Since green skills are imperative resources for EI, the government has to incorporate within the education system. Besides, the government has to establish a stable system to disseminate latest environmental information to firms for developing training modules and awareness. A steady supply of employees with green skills reduces the cost of training and exemplifies the process of EI.

The second policy intervention is through environmental strategies (ES) using Model 2. From all the three models, Model 2 provides greater implications for policy makers. This model connects both Model 1 and 3 via environmental strategies. Environmental strategies are the central mediator and a powerful driver for the entire model. Therefore, policies that provide more liberty for firms to eco-innovate have to focus on motivating factors that stimulate environmental strategies.

IPMA (see Figure 7.2) results indicated that environmental collaboration and export behavior imposed greater importance on environmental strategies as compared with other drivers of ES. The interviews revealed that sharing of best practices provided firms with the latest solutions to solve their environmental issues faster and without any cost. Moreover, firms were able to benchmark their environmental initiatives and determine areas for improvement.

Understanding the importance of environmental collaboration for environmental strategy, policy initiatives that enhance networking and encouragement for research partnership between firms is important. Furthermore, as firms are seeking for faster and cheaper solutions, government can identify best environmental practices from different countries and disseminate this information to the industries.

On the other hand, foreign environmental regulation imposed on exports and foreign affiliations has brought a positive behavioral change among firms. This export behavior leads firms to improve their environmental performance. Besides, the IPMA results revealed that the performance of export behavior on environmental strategies was greater than environmental collaboration. Therefore, for firms to develop proactive environmental strategies, policies promoting exports to countries that impose stringent environmental standards are necessary. This learning exposure will further strengthen the firms' capabilities to eco-innovate.

The final policy intervention should concentrate on the direct effect of environmental regulation and strategies. Environmental regulation has assisted countries worldwide to reduce the damaging impact of manufacturing activities. However, environmental regulation also encourages the industries to employ end-of-pipe solutions, where for long-term, this is not a sustainable option. For Malaysia, environmental regulation remains important because there is no specific policy for EI since it is still at an infancy stage. Malaysia can move away from extreme regulation-driven policy and embrace innovation-oriented environmental policy for long-term sustainability. As opposed to importance, IPMA (see Figure 7.3) results revealed that environmental strategies had greater performance on EI as compared to environmental regulation. Therefore, the policy measures to intensify the drivers of environmental strategies are important for EI.

This study showed that government's efforts to encourage sustainable manufacturing need to be targeted and integrated. Currently, the efforts are segmented between the ministries. This could be the reason for firms to highlight issues such as confusing policy directions and unclear aspects of greening. There is an urgent need for involved ministries to collaborate and develop central strategy to avoid overlapping of policies in order to speed up the EI process. This study proposed a systematic approach for innovation-oriented environmental policies to work. Execution of concise strategies will not only improve the environmental protection performance but also open doors for new economic opportunities.

8.3 Implication

8.3.1 Policy Implication

In light of the results reported in this study, this study claims that for effective environmental policy outcomes, it is imperative for the policy makers to engage actively with the industry. This is extremely necessary for an innovation friendly environmental policy. Firms are heterogeneous in nature; case-by-case approach is necessary to promote innovation friendly EI initiatives. The greatest setback is when the government is unable to determine the correct route to transmit environmental policy signals. Direct environmental policy goals which are totally different from the corporate environmental policy are not parallel with the characteristics of the firms (Kivimaa, 2008b). Therefore, leading to wrong choice of economic instrument to deal promote EI.

Innovation friendly policy encompasses among the following features: industry oriented (i.e., according to strategic planning) flexible (i.e., able to deal handle environmental issues case-by-case basis) and knowledge and management oriented (Janicke et al., 2000). Environmental issues are multifaceted, both the public and private sector have to work together in finding solution to these problems. The following section presents five important suggestions to increase the effectiveness of environmental policies.

8.3.1.1 Effective Transmission of Policy Signals

Effective transmission of environmental policy signal into the industries is important to achieve the environmental policy goals (Kivimaa, 2008b). Government and institutions have frequently placed greater emphasize on networks between firms to transfer policy signals, while networks within a firm requires more consideration when green industry initiatives are implemented (Williander, 2006). Each firm has their own internal network through which their corporate environmental signals are transmitted. Policy makers need to identify these routes to transmit effectively the policy signal within the firms. The result of this study found there are four routes that could be used by the firms to transmit policy signal. The most effective route indicated by this study is through the environmental department. This department plays an extremely important role to promote environmental integration within the firms by bridging the communication gap between the top management and other departments in the firm. From identifying critical environmental issues in the firms to successfully addressing these issues through corporate environmental strategies largely depends on this department. Therefore, active engagement with this department contributes to greater chances of transmitting policy signal within the entire organization.

Another route is through the internal system, which uses a top-down approach to transmit corporate environmental signals. This system has a formal structure with a centralized decision-making mechanism not only to force but also to inculcate strong awareness among employees to increase firm's environmental performance. The ability to transmit policy signals through the internal system provides greater chances for the firms to internalize these signals.

Besides the environmental department and internal system, the provision of environmental training is another potential route. Even though firms centralize the decision-making, the participation of department heads and employees to contribute their ideas to solve environmental issues are encouraged. Furthermore, there is active employee participation in decision-making through cross-functional integration between departments.

Department heads and employees together identify critical environmental problems in the firm and propose the best solution to those problems to the environmental department. Firms are seen to invest a lot to enhance their employee's environmental knowledge and skills through various trainings and awareness programs. Therefore, policy makers are able to infuse policy signals through environmental training. Currently, the government is taking such effort by engaging with CICM and Environment Institute of Malaysia (EiMS). However, greater emphasis is on environmental compliance trainings. Firms infuse their corporate environmental signals through environmental trainings.

Based on firm's experience, there are several recommendations for the policy makers to transmit innovation oriented policy signals through environmental training. Many firms have developed their own environmental syllabus, which consists of several courses developed to tackle specific aspect of environmental issues, for example, technology, emission reduction, carbon reporting and others. Another form of training avenue that firms regards a highly influence to promote EI is engaging with experts by means of sharing best practices. Therefore, government needs to divert from compliance related trainings towards a more environmental technology oriented trainings (i.e., specific types of EI). Government should collaborate with firms that have established environmental technology training courses. This effort will assist other firms to acquire quality environmental technology knowledge and allow the government to signal their policy goals to a wider audience through environmental trainings.

The last route is through environmental knowledge databases. Firms have established structured environmental knowledge databases, which is coordinated by the central system. These databases are always updated with latest environmental solutions and emerging environmental issues, and are frequently used to develop environmental training modules and strategies. The top management, department heads and certain quarters of the employees are able to access the databases anytime to find solutions for immediate environmental problems. Diffusing policy signals through these databases seems to be a viable option for the policy makers.

8.3.1.2 Harmonization of Public and Private Environmental Goals

Environmental policy fails when there is a conflict between public and private environmental goals. For a firm to accept environmental actions taken by the government, they have to be receptive to change. This is possible by intervening their decision making process by influencing their managerial attitude and managerial knowledge related to environmental concern and technological change (Ashford, 2000). Furthermore, the actions proposed by the policies should take into consideration the firms capabilities (Oliver, 1991; Westphal & Zajac, 2001).

EI is driven by similar factors that drives normal innovation in the organization (Kemp, Smith, & Becher, 2000). Large firms have already established their capabilities and routines to innovate. According to the findings, when it comes to improving their environmental performance, large firms are incorporating emerging environmental issues. Under the central system, there are teams of experts with specific environmental knowledge (i.e., technology, waste management, water conservation, emissions reduction and others) at the headquarters to design the primary corporate environmental strategy. As majority of the large firms have similar system and incorporating emerging environmental issues, they encapsulate similar broad aspects in their primary strategy. At the firm level, the top management is responsible to achieve the goals envisioned by the central system. Taking into consideration the capabilities and local regulatory requirements, the top management designs the firm level corporate environmental strategies (i.e., through environmental projects) to gradually achieve the environmental goals set under the central system.

Therefore, by gauging the broad aspects of corporate environmental strategy proposed by the central system, the policy makers are able to determine the direction of EI. This information allows policy makers to harmonize the public environmental policy goals. The synchronization of broad environmental aspects of corporate environmental policies and public policy goals could increase the effectiveness of achieving environmental policy targets as proposed by the government. This synchronization, furthermore, provides the firms similar policy signals, whether it is from the corporate environmental policy and public environmental policy. Additionally, this action by the policy makers could address the weak environmental policy direction issues brought forward by the firms during the interviews. Policy harmonization may increase the predictability of public environmental policy. With similar corporate and public environmental goals to achieve, firms have sufficient time to plan and avoid misallocation of resources (Johnstone et al., 2010). Lastly, the act of totally allowing the large corporations to solve their environmental issues is not practical (Stevens, 2000), as the decisions made by them may not favor the society at large. Thus, policy harmonization could be an avenue for policy makers to intervene and tackle this issue.

8.3.1.3 Choice of Policy Instrument

Firms are the main drivers of innovation, and the incentives given to them determines their performance (Stevens, 2000). The findings from this study showed that the trust placed on the large firms by using a flexible self-compliance regulatory mechanism increases their confidence. The firms exhibit greater responsibility to comply with the environmental regulations and requirements set by the DOE. Thus, it seems a viable choice for the government to move towards a more self-guided regulatory approach especially among large firms. By looking into the present EI scenario in the large firms, the study proposes that informational and voluntary measures are among the suitable economic instruments to increase the level of EI.

According to the findings, informational measures were deemed necessary due to several reasons. First, firms are not clear about the extent of green technology, and the green industry initiatives that are expected from them. Next, firms that have been in the industry for a long time are having trouble to adopt green industry features. This is due to the structure of the factory and old machinery and equipment, which only allows limited alteration. Any drastic transformation will be too costly. Lastly, firms are always demanding for latest knowledge and expertise pertaining to EI and greening their industry and the environmental consultants charge higher fees. Therefore, informational measures such as EI demonstration programs that provide the firms the information regarding the benefits and technical feasibility of the EI (Stevens, 2000) need to be arranged by the government. Moreover, EI exhibitions such as International Greentech & Eco Products Exhibition & Conference Malaysia (IGEM) organized by KeTTHA that provide platform for firm to network and obtain latest information should be organized frequently. These efforts assists the firms in making better decisions and reduces the cost to obtain information, which possibly increases their chances to eco-innovate.

In light of the large chemicals industry, voluntary measures such as disclosure requirements, environmental management systems and extended producer responsibility is another suitable option for policy makers to encourage EI as compared to extremely command and control approaches (Stevens, 2000). The findings indicated that large firms are concerned about their image, and globally, the chemical industries specifically have been under spotlight due to their high polluting track record (Abreu, 2009). For these reasons, firms are not willing to compromise with the environmental standards. Voluntary measures demand greater transparency from firms regarding the efforts made by them to increase their environmental performance. This automatically pressures the firm to create or adopt EIs (Blackman, 2008). Therefore, the government needs to have the right mechanics in place to encourage firm's to participate in these voluntary measures.

Another potential area that the government could assists the firms is by providing a clear and credible price signal on their EI investments (OECD, 2009b). From the findings, it was evident that firms view EI as a business investment. The top management requires a detailed cost benefit analysis for the environmental projects proposed to them, and convincing them to prioritize these projects is a difficult task for the top management. These environmental projects, which increase firms environmental performance, is also expected to contribute to business profits. Hence, sound price signals would assist the firms to make suitable investment decisions to promote EI driven economic growth.

8.3.1.4 Enhance Competitiveness

EI is the driver of international competitiveness and chemical industry is among the major industry that face immense pressure for technological competition as it is exposed to new environmental issues and regulations (Faucheux, 2000). A research by the Japanese government agencies found that during the first half of the 21st century, 40 percent of the world's production of goods and services would be environmental friendly (Miller & Moore, 1994). Therefore, the aspect of competitiveness requires a due consideration within the environmental policy framework. In the case of Malaysia, foreign countries largely influenced the competitiveness of the chemicals and chemical products. The influence was through stringent environmental regulation imposed on Malaysian export by countries with quality environmental regulation system and the foreign ownership that these countries have in local firms. Therefore, for Malaysia to be an eco-product hub and spearhead eco-innovation driven growth, policy makers may increase the foreign influence to increase competitiveness of the chemical products.

Malaysia is viewed as the next location for chemical firms in ASEAN after Europe and US as foreign firms have a strong distribution network in Malaysia. MIDA and MITI have a large role to play, besides promoting investment they need to support the innovative culture within the firms. They need to encourage investments from companies that are exceptionally proud of their environmental achievements. These large players have many environmental guidelines for their supplier (S. Schneider, personal communication, October 8, 2015). The current nature of the chemicals industry in Malaysia, which exhibit strong backward and forward linkages within the sector and between other sectors in the economy cause firms to be under pressure in complying with the guidelines proposed by these environmentally concerned firms. EI then becomes mandatory for those who are willing to comply with the guidelines proposed in order secure a contract and reap the benefits. Next, since chemical firms have actively responded to foreign environmental regulations to increase the competitiveness of the products, efforts that provide access to a wider export markets that place high value of environmental friendly chemical products could be intensified.

Besides using external influence to increase competitiveness, the internal mechanism such as networking and collaborations requires attention from the policy makers. Majority of the firms are networking and collaborating within their groups. This limits the diffusion of environmental knowledge and innovation within the economy. To increase competitiveness, the dynamic interaction between the firms is important to nurture green skills among employees and increase top management commitment towards environmental issues (Hall et al., 2013; van Hoof & Thiell, 2014). Therefore, the government should look into areas to promote strategic partnership between firms to eco-innovate, which could be done by encouraging research collaborations and facilitating networking (Stevens, 2000).

8.3.1.5 Human Capital Development

Through an industrial dialogue, Invest Selangor Berhad found that there is a huge demand for workers in the chemicals industry. However, it is difficult to employ qualified workers because the job in the chemicals industry requires highly skilled workers, and employees are frequently headhunted in this industry (S. Schneider, personal communication, October 8, 2015). The highly capital and technology intensive nature of the chemicals industry entails talents in the area of research and development to develop products that has high economic and environmental value (Lee et al., 2015). Looking into this scenario, policy makers have to tackle this issue to ensure the industry has access to sustainable supply of qualified employees. A proper mechanism is required develop to attract the younger generation to be interested in science and technology field. Additionally, the government has to engage with universities and schools to develop curriculum that produces graduates with the technical skills required by the employers.

8.3.2 Managerial Implication

8.3.2.1 Strengthen the Absorptive Capacity

From the findings, it was obvious that firms are engaging with large amount of external knowledge to develop their environmental strategies to eco-innovate. The knowledge has either directly or indirectly broadened their horizon pertaining environmental issues and solutions. The multilayered approach used to formulate their environmental strategies encouraged more members of the firms to engage with this knowledge and intensify the flow of this codified and tacit knowledge. However, the multilayered approach did not exhibit a formal structure and the management is perceived to work on this aspect.

Lack of formality limits the distribution and assimilation of the external knowledge within the firms, which distorts firms absorptive capacity (Cohen & Levinthal, 1990). The stock of knowledge that the firms have already accumulated and internalized influences their absorptive capacity, which is to obtain, exploit, transform and integrate new knowledge (Zahra & George, 2002). Absorptive capacity facilitates innovation and drives sustainable competitive advantage to increase firms environmental performance (Lenox & King, 2004). Therefore, the management has to find a proper mechanism to effectively capture, distribute and assimilate both external codified and tacit knowledge within the firms to strengthen the absorptive capacity.

8.3.3 Theoretical implication

From the literature review, it was evident that three major fields of study that scholars often referred to when dealing with eco-innovation issues are environmental economics, innovation economics and strategic management. Theories from these there fields are used extensively in deducing the conceptual frameworks. However, these theories have been frequently dealth in isolation as they are constrained by assumptions imposed by different schools of taught. This is especially for innovation related studies and theories stemming from the field of environmental economics. Neo-classical theory driven by the environmental economist largely examines effects of environmental policy instruments to stimulate eco-innovation. The dynamic efficiency criterion is given greater weightage by them, which is to establish a specific environmental policy instruments (i.e., pollution charges, subsidies and other) that provide an incentive for firms to eco-innovate. However, the modeling is done within ideal conditions (i.e., where the economy is competitive, exhibit low transaction cost and quickly adapts), which according to present conditions is not realistic. A realistic EI framework should take into consideration a better understanding of the emitter's structure (Janicke et al., 2000), and to develop a holistic EI framework that incorporates the emitter's structure that requires the understanding of firm's capabilities and routines. This is only possible by merging the field of economics and management, which is still limited (del Río et al., 2016).

The qualitative study that was executed to deliberately develop the EI framework confirmed that the understanding of the emitter's entire organizational and environmental management structure was important before an effective EI framework was developed. Therefore, to establish this understanding in depth knowledge of the demand side and supply side factors that influence firm's capabilities and routines is imperative. A matter of fact, the evolutionary approach of innovation economics has long emphasized the importance of these factors to promote EI (Pavitt, 1984; Rennings, 2000). From the findings, it was evident that evolutionary perspective to EI that merges theories from the three fields mentioned earlier especially theory of induced innovation, evolutionary economic theory, resource-based theory, dynamic capabilities theory and stakeholder theory may serve a better platform to develop an effective EI framework. This is because the EI determinants are strongly interlinked. Additionally, the imperative EI determinants work according to the certain preconditions that need to be established first.

In general, the study argues that if sector specific actions are important to promote EI, future works that deals with establishing sector specific EI framework have to consider eco-innovation knowledge and theories from the field of economics, innovation and management. The journey to eco-innovate is evolutionary in perspective as the EI determinants are interlinked. Therefore, for effective EI framework and outcome, the knowledge of firm capabilities and routines that influence their corporate environmental strategies is important for policy makers to harmonize public environmental policies with corporate environmental policies.

8.4 Limitations and Future Direction of Research

This study offers the framework and determinants to promote EI specifically for the chemical manufacturing industry in Malaysia. However, there are several limitations. First, there is a possibility for observer biasness and error to take place and affect the reliability of this study. This is because the study heavily depends on notes taken during the interview, which may cause data loss (i.e., observer error). Since the topic of the study is in the interest of the researcher, the behavior of the respondents during the interviews may possibly cause underestimation or overestimation of information during reporting and interpretation stages (i.e., observer bias). Largely this problem was countered by following up with a qualitative study (i.e. executed in the similar industry setting), frequent discussions with experts from the related field and supervisors.

Next, the environmental stringency was measured through perceived stringency, which is not the best measure. A large number of studies have used this method, but it may have been preferable if there was a solid measure such as pollution abatement and control expenditure (PACE). This study was unable to employ such measure due to the limited availability of the data in Malaysia. Over the years, the Malaysian environmental regulation has improved and is stringent compared to earlier years. If a more solid measure was available, the results of environmental regulation stringency on EI could have been better.

Lastly, the study is based on a single industry case study; the chemical manufacturing industry, thus generalization of the results is limited. Lately, EI has gained attention from the Malaysian government to act as a catalyst for the green economic growth. However, study related to EI is still scarce in the local context. This limits the ability to triangulate the findings of this study with other sectors to support generalization to other sectors. Therefore, similar study is required in other industry settings to allow generalization of the findings and to better understand EI and its determinants.

In terms of future direction of research, the main aspect that requires immediate attention is the EI framework itself. The framework needs to be tested in other industries, to assess the industrial similarities and differences, to promote EI, as each industry is unique in its own ways. Furthermore, this action will assist the generalization of the present study's findings into other sectors. Besides the framework, the state of EI in other sectors also needs to be gauged to understand the sustainable manufacturing practices employed by the sectors. Both this information is essential for the government to design a national level EI framework that provides attention to industry specific needs.

Another aspect that need future attention is related to collaborations and networking within the chemical manufacturing industry. Effective innovation is expected to transpire between firms in the similar cluster (Stevens, 2000) and Malaysia has clustered the industries since the second Industrial Master Plan in 1996. However, from the study, it was found that collaborations and networking within the chemicals industry cluster to eco-innovate is scant. Therefore, an in-depth qualitative study is required to determine the reason why this is happening and how the government can address this issue.

Lastly, a more focused empirical analysis is required to determine the relationship between foreign influence and EI. From this study, firms with foreign ownership, foreign headquarters location and with exports to countries with stringent environmental regulations were found to strongly influence the introduction of EI. However, the present study is limited from the aspect of empirically testing this relationship. Therefore, this area requires further attention and a more robust analysis.

8.5 Summary

This chapter recapitulated the main qualitative and quantitative findings from chapter 5 and 7 respectively. Additionally, this chapter merged both the findings to provide a more robust discussion and implications for policy makers and business managers. The highlights of this chapter are discussion related to imperative EI determinants. Environmental strategy was found to be the most important determinants and the central determinant that connected all other determinants together. Aspects related to environmental strategies that increased its effectiveness are related to firm structure and culture that have inculcated the values to protect the environment and increase firm's environmental performance. To instill these values among the employees, top management has played an extremely important role. From the very beginning, they have promoted environmental integration within the firms to spread the environmental ideologies advanced by their headquarters, which was executed through cross-functional integration between departments, using top-down approach, environmental trainings and environmental databases. Besides environmental strategies, foreign influence through foreign environmental regulations and foreign ownership was also found to shape firms behavior to eco-innovate. Lastly, as the chemical industry is its own biggest buyer and seller, the consumer pressure from within the industry may have largely influence the firms to eco-innovate as well.

On the implication front, policy implication focuses on several aspects. Among the aspects is the selection of an effective route to transmit policy signals, by providing environmental trainings, engaging with top management, connecting with firm's environmental databases and environmental department. Next aspect is the choice of policy instrument. The current scenario depicts that policy instrument that uses informational measure would effectively promote EI, as firms have lack of understanding and scant information pertaining to EI. Additionally, provision of credible price signals for EI related investment is also suggested as EI is still a new area, and firms are not clear on the potential financial returns from this area. Other aspects that were found to be important in order increase the effectiveness of environmental policy is the harmonization of public and private sector environmental goals, human capital development and by increasing the competitiveness of the industry.

In terms of managerial implications, the top management is suggested to strengthen their absorptive capacity. This is because, members of the firms are engaging with huge amount of external information to formulate their environmental strategies, without a proper mechanism to capture this codified and tacit knowledge. Lastly, for theoretical implication, it was found that theories stemming from the field of environmental economics, innovations economics, strategic management and organizational management play an important role to develop EI framework. Therefore, the merger of the above mentioned fields are vital to effectively bring the EI determinants to gather for an effective EI framework.

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