A STUDY ON KNOWLEDGE CONTENT IN KEY ECONOMIC SECTORS IN MALAYSIA PHASE III (MYKE III) – FINAL REPORT (PHASE 1)

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FINAL REPORT (PHASE 1)

SEPTEMBER 2016

EPU
ECONOMIC PLANNING UNIT
PRIME MINISTER'S DEPARTMENT, MALAYSIA

MONASH University
MALAYSIA

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FINAL REPORT – PHASE 1

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PHASE III

(MYKE III)

Confidential

14 September 2016



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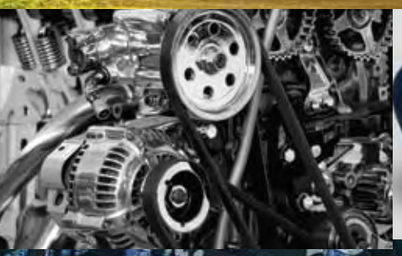

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Table of Contents

Executive Summary

Malaysia, like all other developing countries, has a vision of becoming a knowledge-based economy. To achieve this vision, the Malaysian government has introduced a number of plans and programmes to assist local firms to increase their knowledge content and innovative capacity. To measure the effectiveness of the various government plans in improving knowledge intensity among Malaysian firms, *the Knowledge Content in Economic Sectors Phase I* (MYKE-I) was conducted in 2003. A second study called, MYKE-II was conducted in 2007. This study is the third study (MTKE-III) to measure knowledge content of Malaysian firms (MYKE-III). This study examines the knowledge content and innovative capacity of 21 industries, and in the process of doing so it will identify key strengths and gaps in the knowledge ecosystems of the studied 21 industries and evaluate them on their ability to successfully move up the knowledge and innovation value chain.

In this study, a novel knowledge ecosystem model was used to measure the knowledge content of the 21 industries, which consists of the following broad components: *Knowledge Enablers* (Basic Skills Development; Market Intelligence; Institutions – Government, Trade Associations and Universities; Science & Technology Knowledge; Advanced Skills Development; and Knowledge Culture in organisation); *Dynamic Capabilities* (Absorptive capability; Adaptive capability; and Innovative capability); and *Economic Outcomes* (Process Improvement and Product market outcomes).

Qualitative and quantitative research methodologies were used for the MYKE-III. For the qualitative analysis 189 interviews and focus group studies were conducted across the country. For the quantitative analysis, a sample of 2,348 firms was obtained from Department of Statistics, Malaysia.

The key findings of the study are reported below:

- The 21 industries can be classified into four categories (Pace-Setter, Adapter, Imitator and Laggard) based on the level of knowledge content and innovative capacity.
  - The Pace-Setter industries are: Food Processing; Chemicals, Petroleum & Pharmaceuticals; Electrical & Electronics; Financial Services; Telecommunications & Courier Services; IT Services; and Automotive.
  - The Adapter industries are: Rubber & Plastic Products; Fabricated Metals; Education Services; and Tourism Services.
  - The Imitator industries are: Transport Equipment; Machinery & Instruments; Transportation Services; Business Services; and Wholesale & Retail.
  - The Laggard industries are: Agriculture; Wood-Based Products; Textile, Apparel & Footwear; Health Services; and Construction sectors.
- The study also found the following industries to be important knowledge enablers for the Malaysian economy: IT Services; Business Services; Education Services; Financial Services; Transportation Services; Electrical and Electronics; Machinery and Instrumentation; and Chemical, Petroleum and Pharmaceutical.
- The study found that, while there has been significant progress over the years in developing the knowledge ecosystems for the 21 industries; the ecosystems lag behind industries in more developed countries.
- For all industries public institutions (government agencies, trade associations, universities and learning institutions) play an important role in influencing the knowledge enablers; but they do not have a direct impact on the dynamic capability components. In advanced countries, similar institutions have a dual role in influencing the knowledge enablers and the dynamic capability components.
- Key challenges encountered by industries classified as Laggard are as follows: institutions to develop knowledge are not well coordinated; there is a low level of basic skills development due to a transient labour market; shortage of talented staff; a major brain-drain problem; over-dependence on foreign technology – there is a 'lock-in' phenomena; there are weak linkages between key stakeholders which hinder knowledge sharing; the adoption of technology is low; many SMEs are not savvy in the use of technology and the knowledge networks to gather market intelligence. The knowledge-enablers primarily influence absorptive and adaptive capability, leading to process improvement only. The knowledge ecosystem is not sufficiently strong to create or enhance innovative capability and product market outcomes.
- Key challenges encountered by industries classified as Imitator are as follows: weak coordination by key institutions hinders strategic development of industry; the industries in this stage of development are dependent on foreign technology; most of the skills training and development are catered to the use of foreign technology to improve process improvement. Some firms in this group attempt to achieve product market outcomes thought incremental innovation strategies; however, most of the products are not high-value-added products and are therefore unlikely to deliver sustainable long-term competitive success.
- Key challenges encountered by industries classified as Adapter are as follows: lack of coordination among key institutions has led to ad hoc development of the industries. One of the major challenges encountered by this group of firms is the lack of talent, especially technically competent and knowledge workers due to the high cost of training and prevalent talent poaching, a low investment in R&D activities and absence of knowledge culture. Firms take a hierarchical approach to managing innovation, which stifles creativity and knowledge sharing among workers. Most of the advanced skills are only able to develop absorptive and adaptive capabilities, yielding only incremental process improvements. Product market development is limited among firms in industries classified within this grouping.
- Key challenges encountered by industries classified as Pace-Setters are as follows: In this group of industries, there is stronger cooperation among key institutions as well as a significant number of strategic plans in place. However, many of the key milestones are not tracked on a regular basis creating weak alignment of firms with major technological, demographic and other shifts taking place within the domestic and global markets. The ecosystems in these industries are not agile, and are unable to adapt quickly under pressure from internal and external changes. A major hindrance to developing knowledge content in many of the industries is the lack of a steady stream of creative talent, especially in the scientific and technical fields. There is also lack of sharing of best practices among firms, and the inadequacy of mechanisms in facilitating knowledge-spill over among firms, especially from larger firms to SMEs. Most firms possess hierarchical organisation structures that hinder creativity and remain dependent on foreign technology and knowledge. The firms in this group were found to be able to develop all three dynamic capabilities (absorptive, adaptive and innovative capabilities), yet the level of dynamic capability is sufficient only to generate incremental process improvement and product market development.

In general, the study shows that, although the 21 industries have made significant improvements in developing the knowledge ecosystem, the scope under this ecosystem for a significant number of firms in the industries to move up the knowledge and innovation value chain is limited and gradualist. Slow progress is attributed to weakness inherent in the knowledge ecosystems in these industries. In light of weaknesses or gaps, the study provides recommendations on specific strategies, policies and best practices each industry can pursue to strengthen their knowledge ecosystems and enhance their knowledge intensity. The recommendations from the 21 industries can be summarised into 5 strategic thrusts:

- ***Strategic Thrust 1: A Holistic Talent Development Strategy for a Knowledge-Intensive Economy.***
  The global economy is undergoing rapid transformation, powered by rapid technological changes and converging technology platforms. Institutions need to work together to predict and signpost changes taking place in the economy. It is necessary to continuously review and realign education and training programs to create a labour force that meets the future needs of Malaysian industry. This includes intensifying directed technical education and vocational (TEVT) training; and investing in resources that will nurture the next-generation of creative talent for specific industries. Best practices on developing creative talent from advanced countries are provided in the report.

- ***Strategic Thrust 2: Focus and Invest in R&D Frontier Technologies to Enable Malaysian Industries to 'Leap-Frog' to Higher Level of Innovation in the Value Chain.***
  All industries should foresight key technologies that will shape the future of the industries; and channel appropriate resources for R&D investment, infrastructure development, personnel, incentives and support systems to help the development of their dynamic capabilities in key research priority areas. The R&D investment should target translational research outcomes in terms of generating process improvement and product development. Establishment of centres of excellence (CoEs) in key research priority areas for the 21 industries will be critical for raising the knowledge content and innovative capacity of the industries. The CoEs need to work closely with industry to ensure R&D undertaken is relevant to the industry. Close linkage between CoEs and industry is critical for generating the ready supply of relevant research personnel. Best practices to develop and sustain frontier R&D and innovation based on advanced country experiences are provided in the report.

- ***Strategic Thrust 3: Nurture Next-Generation Leaders to Power Malaysia's Knowledge Economy.***
  One of the gaps in the ecosystems for the 21 industries is the insufficiency of visionary leaders who are able to empower employees to undertake path-breaking R&D; and be take risks in charting new frontiers of innovation. Malaysia hosts a number of excellent leadership programs, such as the ones found in the Finance industry. These programs train next generation workers to be creative and inculcate a culture of taking calculated risk taking. The programs trains leaders to differentiate between "red-alert risks" and "green-alert risks". Infrastructure and support are provided for workers to learn to take "green-alert risks". Similar types of industry leadership programs should be designed and delivered for firms in other industries to enable workers to achieve the following: be ambidextrous in balancing short-term and long-term priorities; have high emotional intelligence; acquire the ability to foster practical wisdom in others; and have the ability to mentor others in strategic decision-making and develop a sustained career trajectory. A number of best practices are provided in the report.

- ***Strategic Thrust 4: Strengthen 'Quadruple-Helix' to Create Multiplier Effect.***
  One of the key gaps in the knowledge ecosystems of most industries is weak collaboration and engagement among key stakeholders in the economy. A wide range of approaches have been proposed to nurture strong partnerships between industry, government agencies, industry associations, universities and training institutions. Among them include devising appropriate institutional frameworks, technology, governance systems and incentives (fiscal and non-fiscal) to enable the industries to strengthen their network externalities such that they lead to higher knowledge creation and diffusion in the industry. Best practices to develop strong industrial clusters from advanced countries are provided in the report.

- ***Strategic Thrust 5: Nurture a Business Friendly Knowledge Ecosystem.***
  A challenge encountered by firms in a number of industries is the lack of a holistic support system to help firms acquire the necessary information, knowledge and resources to make informed decisions. In most instances, the knowledge systems are plagued by bureaucracy, duplication and inflexible processes that hinder knowledge acquisition for use in creation processes. To ensure all 21 industries are able to transition to become more knowledge intensive, the following support systems should be in place in the ecosystems: testing and proto-typing facilities; simplified and streamlined certification approvals; availability of good business services, such as marketing, branding, legal, human resources and others; adequate funding for SMEs and start-ups; assistance for firms to internationalise their operations; incentives for technology adoption among SMEs; access to R&D funding, technical support, research infrastructure and expertise; a robust and sound patenting ecosystem; and sound regulatory and legal system. A business friendly ecosystem will not only reduce cost and increase operational efficiency, but attract high quality foreign direct investment and talent. Best practices to develop a business-friendly environment from advanced countries are elaborated on later.

In summary, the MYKE-III study provides valuable insights on the key gaps in the knowledge ecosystems in the 21 industries. The study also provides recommendations on strengthening the knowledge enablers within the ecosystems so as to ensure that all three dynamic capabilities components (absorptive, adaptive and innovative capabilities) are able to lead to process improvement and product development. Appropriate strengthening of the dynamic capabilities of Malaysian firms will raise the global competitiveness of the 21 industries and the Malaysian economy.

CHAPTER 1
Knowledge Content in Key Economic Sectors in Malaysia

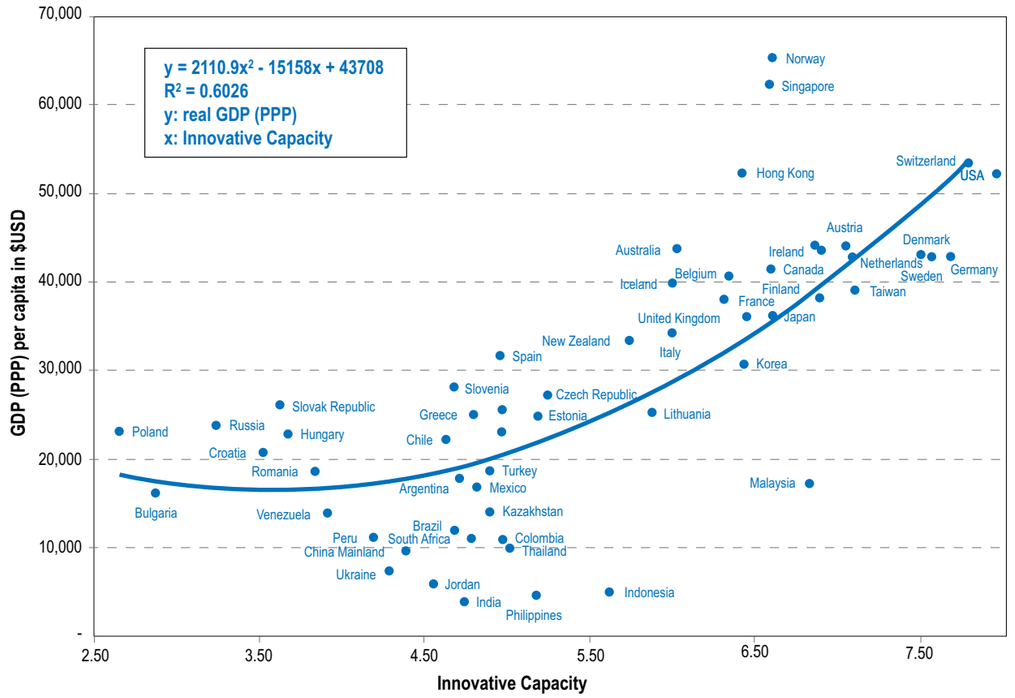
1.0 Introduction

It is widely accepted that a focus on knowledge intensity is critical for firms to move up the innovation value chain, and enables them to transcend scarcity of traditional factors of production such as land, labour and capital to enhance their competitiveness (Arrow, 1962; Lucas, 1988; Romer, 1990; Mani, 2004). New knowledge and technology enable firms to decouple from the 'space-time' continuum and extend their reach for resources and markets at the click of a button. Romer (1990) argued that accumulation of knowledge (especially R&D) has two major spill-over effects for firms: (i) it leads to new products and services, enabling firms to pursue economies of scope; (ii) it enhances innovative capacity and productivity – a source of increasing returns to scale.

While new technological breakthroughs have powered a greater diffusion of knowledge across the globe; widening disparities in the acquisition and utilisation of knowledge have increased the wealth gap between countries (Romer, 1986; Lucas, 1988; Barro, 1990; Persaud, 2001; Porter & Stern, 2002). **Figure 1.1** shows that countries with high innovative capacity also record high wealth accumulation with increasing returns to scale. This is because innovative capacity is strongly correlated with wealth creation opportunities - close to 60% of the variation of various countries' real gross domestic product (GDP) is explained by variation in innovative capacity. Key drivers for innovative capacity of countries have been studied in the literature and among them include: technological infrastructure, human capital development, knowledge culture, quality of institutions, corporate governance, dynamic capability factors, market conditions, incentive systems (fiscal and non-fiscal) and degree of industrial and knowledge cluster development (Stern, Porter and Furman, 1999, Porter & Stern, 2002, Wang & Ahmed, 2007; Nair & Shariffadeen, 2009).

In order to be globally competitive, countries across the globe have put in place strategies to enhance the knowledge content and innovative capacity of their firms in their countries. Malaysia like all other countries introduced a series of plans and policies to move firms up the global innovation value chain. The Malaysian economy has undergone major structural changes since independence in 1957 due to pro-development economic policies implemented by the Malaysian government. Much of the economic development in the 1960s to the late 1970s under the 5-year economic plans called the *1st Malaysia Plan (1966-1970), 2nd Malaysia Plan (1971-1975)* and *3rd Malaysia Plan (1976-1980)* was in the agriculture sector, which saw greater efficiency and productivity. This is as agriculture was the main provider of employment and income. Introduction of new technology, farming methods and farm management systems saw increasing agriculture yields, catapulting Malaysia into its status as a global player in the production of natural rubber and palm-oil (Economic Planning Unit [EPU], 1965, 1971, 1976).

Figure 1.1: Relationship between Innovative Capacity and Wealth in 2013



Note: National Innovative Capacity is defined as the ability of a country of producing a stream of innovations that are commercially viable for a long period of time (Porter & Stern, 2002). National Innovative Capacity is measured by an Executive Survey Question called -Innovative capacity of firms, which measures the ability of firms to generate new products, processes and/or services. If the survey questions score is 0, it means that the innovative capacity is low; if the score is 10, it means that the innovative capacity is high in the economy.

Data Source: IMD (2014), World Competitiveness Online Database.

Increased volatility in the commodity prices and its adverse impact on the Malaysian economy forced the nation to find an alternate engine of economic growth. To diversify national revenue streams, the nation embarked on an ambitious plan to become a regional industrial powerhouse. Under the *4th Malaysia Plan (1981-1985)*, the government opened the economy to foreign investments, in particular investment in high-tech sectors from Japan and Korea in what became known as the *Look East Policy* (Economic Planning Unit [EPU], 1981). Under the *5th Malaysia Plan (1986-1990), 6th Malaysia Plan (1991-1995), 7th Malaysia Plan (1996-2000)* and *8th Malaysia Plan (2001-2006)*, major investments were channelled into diversifying existing industrial sectors and the promotion of heavy industries, in particular the automobile, electrical & electronic, and ICT sectors (Economic Planning Unit [EPU], 1986, 1991, 1996, 2001).

By the late 1980s, Malaysia was the largest global Electrical and Electronic (E&E) components exporter and the manufacturing sector took the place of agriculture as the largest contributor to the national income. By the middle of 1990s, information revolution was transforming the global economy and there was a concerted effort by the government to transform Malaysia into an information-driven economy. Under the 7th Malaysia Plan, the *National IT Agenda* (NITA) was rolled out with major investments aimed to improve the national ICT infrastructure. A key initiative of NITA was the *Multimedia Super Corridor* (MSC), which was established in 1996. The MSC plan provided a platform to attract greater collaboration

between local and foreign firms to develop the creative and value-adding ICT sector.

The 1997-1998 Asian Financial Crisis forced Malaysia to focus on technological development, including the MSC initiative to propel the economy to into a higher innovation trajectory. The launch of the *Knowledge Economy Master Plan* in 2000 set the stage for the transition of the Malaysian economy into a knowledge-driven and developed economy (Institute of Strategic and International Studies Malaysia [ISIS], 2002). Part of the plan was to create a conducive environment for international firms to develop and innovate new technology and designs. This is done through incentives such as tax deductions, subsidies, technology start-up funds and management expertise to transform traditional sectors such agriculture into technology- and knowledge-driven sectors using new breakthroughs in biotechnology and ICT. During this period, greater focus and financial support were given to strengthen the position of key services sectors such as tourism, education, global outsources and finance.

The *Knowledge Economy Master Plan* in 2002 acknowledged that for Malaysia to move up the knowledge value chain, knowledge-based workers are critical. The study highlights that Malaysia lags behind other developed countries in terms of highly skilled work force, especially those with tertiary, technical and research qualifications. A number of strategies have been introduced in the subsequent five year economic plans (8th, 9th and 10th Malaysia Plans), the *Second Industrial Master Plan:* 1996-2005 (Ministry of International Trade and Industry [MITI], 1996), the *Third Industrial Master Plan*: 2006-2020 (MITI, 2006) and the *Malaysian Education Blueprint 2013-2025* (Ministry of Education, 2013) to raise the quantity and quality of human capital development in the country. Key policies and strategies to enhance human capital development include the following:

- *Reforms in the education sector* - ensuring entrance qualifications for teaching positions; introduction of a new performance appraisal system; better career prospects and remuneration packages for teachers; incorporation of creative teaching methods using new technology; and introduction of entrepreneurial studies in secondary curriculum.
- *Reforms in the higher education sector* - privatisation of higher education, which includes opening the tertiary education sector to leading foreign university branch campuses in Malaysia; and transforming Malaysia into a regional centre of education excellence.
- *Enhancing quality of education* - introduction of rating systems for colleges and universities; establishing the Malaysian Qualification Agency to ensure that Malaysian tertiary education is on par with other developed countries; developing t technical education that is aligned to the needs of a changing national industrial development landscape.
- Introduction of courses and programs in tertiary institutions that encourage life-long learning.
- *Enhancing R&D activities* – establishment of research universities; increase in research funding for universities and scholarships for doctoral programs in key priority areas that will spur innovations and the next generation industries.
- *Centre of Excellence in key priority areas* - the establishment of Higher Centre of Excellence in universities to drive frontier R&D, foster stronger 'quadruple-helix' and train the next generation researchers who will power Malaysia's knowledge economy.

Under the *9th Malaysia Plan (2006-2010)* the enabling environment for an innovation-driven economy was further intensified against the backdrop of global uncertainties due to the economic slowdown in many of the developed countries and increasing competition from regional economic superpowers such as China, India and Indonesia (EPU, 2006). To mitigate economic uncertainties, the Malaysian government increased funding for human capital development, upgrading of ICT infrastructure, as well as investments in R&D activities in emerging areas such as solar technology, biotechnology and green technology. Focus was also given to improving the service quality of the public sector through a more transparent and business friendly environment.

Global uncertainties continued into the end of the *9th Malaysia Plan* and to weather the turbulent economic landscape, the *10th Malaysia Plan* introduced a series of blueprints to strengthen the national innovation ecosystem. The *New Economic Model* and the *10th Malaysia Plan* (2011-2015) were launched to set the foundation for Malaysia to become a high income nation by 2020. This entailed increasing the per capita income to USD15,000 (RM48,000) by 2020 (National Economic Advisory Council [NEAC], 2010a, 2010b; EPU, 2010). As achieve this aim, the government introduced the *Economic Transformation Programme* (ETP) that focused on developing 12 National Key Economic Areas (NKEAs) that will assist the nation to transform into a high income economy. To enable Malaysia to become a knowledge-intensive economy, the government introduced the *Government Transformation Programme* (GTP) to enhance innovation in the public sector; and *National Key Result Areas* (NKRAs) to improve the national innovation ecosystem by reducing crime, combatting corruption, improving the quality of education, increasing the standard of living for poor and marginalised communities and improving the transportation system (Performance Management and Delivery Unit [PEMANDU], 2010a, 2010b).

The brief summary of national policies, plans and programmes above shows that the Malaysian government has been pro-active in assisting firms to move-up the knowledge and innovation value chain. To ascertain the effectiveness of the various government initiatives in improving the knowledge intensity and competitiveness of Malaysian firms, the EPU conducted a study called the *Knowledge Content in Economic Sectors Phase I* (MYKE-I) in 2003. Subsequently, a second study called MYKE-II was conducted in 2007. Both studies provided valuable insights into the level of knowledge content among Malaysian firms and the types of intervention strategies that will enable firms to increase their knowledge intensity. The information obtained from these two studies informed the *9th Malaysia Plan and the 10th Malaysia Plan* on the types of programmes to improve knowledge intensity among Malaysian firms.

In line with the first two knowledge content studies (MYKE-I and MYKE-II), a third study on knowledge content and intensity of Malaysian firms (MYKE-III) was proposed to ascertain the level of change in the knowledge content among Malaysia firms since the last study in 2007. The proposed study will assess if the policies and strategies implemented under the previous plans were successful in improving knowledge intensity of Malaysian firms. The study will also identify key sectors that have moved up the innovation value chain and examine the key factors that have enhanced or hindered knowledge intensity among Malaysian firms.

Results from the MYKE-III will inform policy-makers and other stakeholders on the types of policies, strategies and intervention programmes that should be implemented under the 11th Malaysia Plan (2016-2020) to strengthen knowledge intensity among corporate Malaysia and set a strong foundation for the transformation of Malaysia into a high income economy by 2020.

This chapter is outlined as follows. In Section 1.1, we outline the knowledge ecosystem model used in this study. Section 1.2 provides the qualitative research method in the study. Section 1.3 discusses the quantitative research methodology to capture the knowledge ecosystem for the 21 economic industries in Malaysia. Finally, in Section 1.4, the organisation of the remaining chapters is outlined.

1.1 The Knowledge Ecosystem Model

To understand the 'knowledge-wealth' chasm in the 21 industries in Malaysia, a review of the MYKE I, MYKE II and MYKE III was undertaken to investigate the level of knowledge content among firms in 21 industries in Malaysia. In this context, the MYKE I and MYKE II studies defined **knowledge content** as:

"the sum of human capabilities, leadership assets and experience, technology and information capital, collaborative relationships, intellectual property, information stocks, and capabilities for shared learning and utilisation that can be used to create wealth and foster economic competitiveness" (Economic Planning Unit [EPU], 2009, p.16).

Based on this definition, the two studies conceptualised a knowledge content measurement model that encompasses four *Knowledge enablers* (Human capabilities; knowledge leadership; technology or infostructure; knowledge environment) and *four knowledge actions* (Knowledge generation; knowledge acquisition; knowledge sharing; knowledge utilisation). These knowledge enablers and knowledge actions represent knowledge components of the model and subsequently lead to two knowledge outcomes: innovation (new or improved product/new or improved process, and improved organisation); and economic performance (improved productivity, enhanced profits) (see **Figure 1.2**).

Subsequently MYKE II adopted the same conceptual model of knowledge content developed in MYKE I. For MYKE III, the original MYKE model was modified to incorporate a number of new instruments and the new model is shown in **Figure 1.3.**

The first two MYKEs relied on nation-wide primary data collected in 2003 and 2007. MYKE III only used the same sampling frame used in MYKE II for the primary data, but the study also conducted qualitative analysis to supplement the findings from the quantitative analysis.

Figure 1.2: Conceptual Model of Knowledge Content

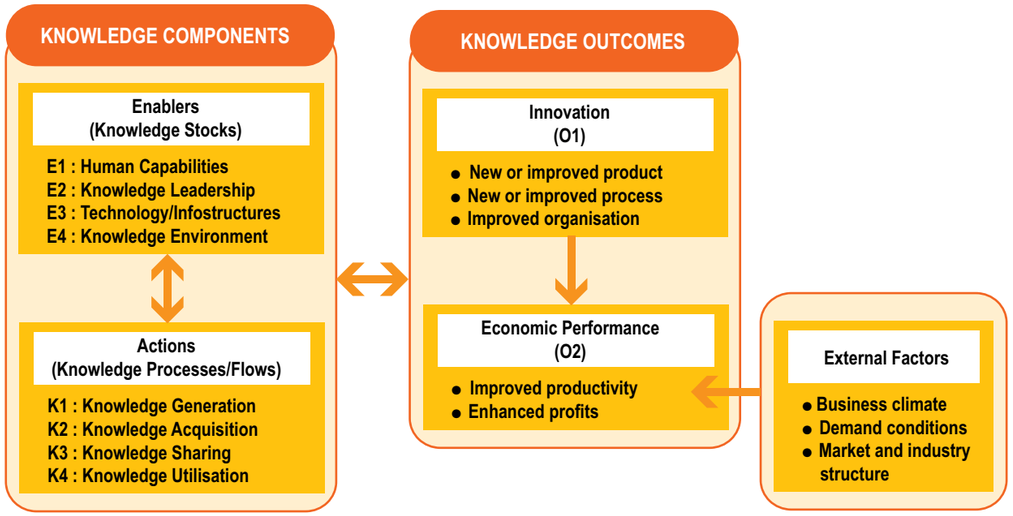
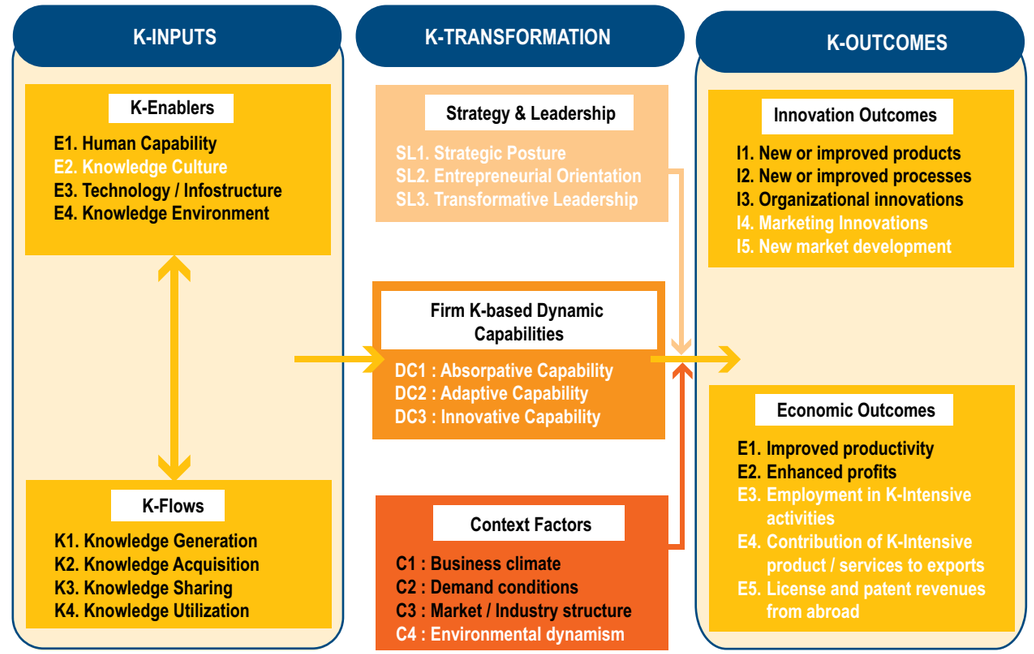


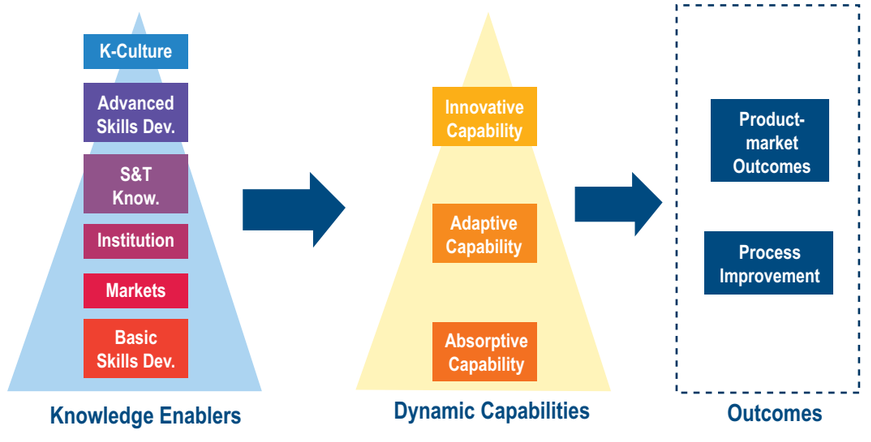
Figure 1.3: Conceptual for the Knowledge Ecosystem for MYKE III



Note: modifications to the MYKE II model are given in white.

In the MYKE III (Phase 1), the above framework was modified to include a new component called dynamic capability, which includes absorbability capability, adaptive capability and innovative capability. The new model is shown in **Figure 1.4** below.

Figure 1.4: The Working Knowledge Ecosystem Model for MYKE III



The MYKE III knowledge ecosystem model consists of three broad components, which include the following:

- ***Knowledge Enablers***
  - Basic Skills Development;
  - Market Intelligence;
  - Institutions – Government, Trade Associations and Universities;
  - Science & Technology Knowledge;
  - Advanced Skills Development; and
  - Knowledge Culture in organisation.
- ***Dynamic Capabilities***
  - Absorptive capability;
  - Adaptive capability; and
  - Innovative capability.
- ***Economic Outcomes***
  - Process Improvement; and
  - Product market outcomes.

Detailed descriptions of the constructs are given in **Table 1.1**

Table 1.1: Descriptions of the Constructs Used in the MYKE III Model

No	Constructs	Descriptions
1	Basic Skills Development	Use of knowledge gained through experience or on-the-job training and learning (non-managerial/basic competency).
2	Market Intelligence	Intelligence gained or provided by: • Suppliers (e.g. equipment, materials, components or software). • Customers. • Clients or users. • Competitors. • External consultants.
3	Institutions	• Universities or other higher education institutes. • Government research organizations. • Other public business assistance or technical or training centres. • Trade associations; local or national business organizations.
4	Science & Technology (S&T) Knowledge	Acquisition of higher order S&T capability via the following channels: • Engagement with conferences, seminars, technical meetings, professional societies. • Access and contribution to journals & technical papers. • Online information sources. • Fairs, exhibitions. • External accreditation and certifications.
5	Advanced Skills Development	Higher-order specialist skills and expertise; • Employees are creative and bright. • Employees develop new ideas and knowledge.

Table 1.1: Descriptions of the Constructs Used in the MYKE III Model (cont'd)

No	Constructs	Descriptions
6	Knowledge Culture in organisation	• Improving knowledge capabilities is one of our most important business priorities at present. • Our employees are motivated to learn new skills. • We have trade secrets or know-how that we carefully protect. • Our competitiveness is based more on informal (tacit) knowledge, rather than formal (documented, codified) knowledge. • We know who to ask for good advice to improve our knowledge capabilities.
7	Absorptive Capability	• Scan the market environment for new customer insights and opportunities. • Acquire technologies from external sources. • Regular meetings/workshops to fully understand, learn and then transfer new knowledge into all parts of the organization. • Systematically store market and technological knowledge for future reference. • Collect and communicate relevant knowledge across the units of our firm.
8	Adaptive Capability	• Financially committed to improve technology and innovation. • Continuously invest to improve our marketing capability. • Have sufficient resources (employees, finances, R & D know-how) to be able to respond quickly to new opportunities. • Develop new structures and processes (e.g., new administrative processes, staff development programmes, rules and procedures) that align with external changes.
9	Innovative Capability	• Leverage our existing market knowledge and technological capability in the development of improved new products/services/processes. • Integrate resources and knowledge-base to enter new markets. • Quickly set-up product development teams once we identify a good business opportunity.
10	Process Improvement	• Technologically new or significantly improved processes for producing or supplying products (goods or services). • New or significantly improved internal management or organizational methods. • New or significantly improved marketing concepts/strategies.
11	Product market outcomes	• Introduced products/services that were new to the firm. • Introduced products/services that were completely new to the market.

Table 1.2: List of 21 Industries Selected for MYKE III Based on DOSM Classification Industries

Industries	Industries
1. Agriculture	12. Tertiary education
2. Food processing	13. Transport (ports, airports and shipping)
3. Chemicals, petroleum and pharmaceuticals	14. Finance (Head Office)
4. Rubber and plastic products	15. Tourism
5. Wood-based products	16. Telecommunication and Courier (Head Office)
6. Fabricated metals	17. Health
7. Automotive	18. Information Technology
8. Transport equipment	19. Business Services
9. Textile, wearing apparel & footwear	20. Wholesale and retail trade
10. Electrical and electronics	21. Construction
11. Machinery and instruments	

Using the framework shown in **Figure 1.4**, the knowledge ecosystem model for 21 industries given in **Table 1.2** was estimated using a sample obtained from Department of Statistics Malaysia (DOSM).

1.2 Qualitative Research Methodology

In this study, qualitative research methods were used to understand the relationships between the selected knowledge enabler, dynamic capabilities and economic outcomes. The qualitative analysis comprised two components, outlined below:

- **Focus Groups**: This is to gain sector specific insights through a process of leveraging on group dynamics to build sector specific and firm level insights.

- **In-depth interviews:** This is to build insights into individual firms as well as sector specific insights through a process of talking to key individuals representing the industry.

The procedure used to recruit participants for the qualitative component of MYKE-III is provided below:

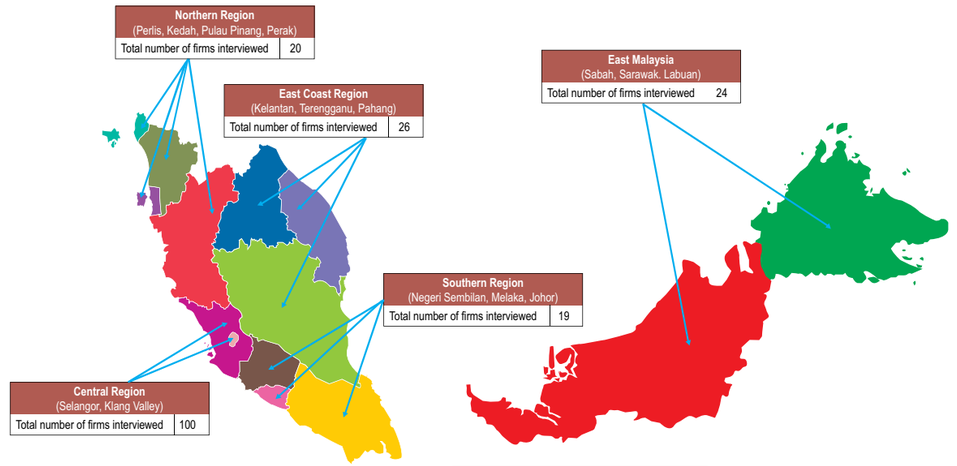
- Following Monash University Malaysia procedures, an application for ethics clearance for data collection was made. This detailed the exact nature of data collection procedure. Once the approval was obtained, preparation for data collection began in earnest.

- A list of firms from multiple sources was compiled.

- A team of researchers from Monash University Malaysia have contacted a number of relevant industry associations across from the targeted 21 sectors for assistance to coordinate meetings with the relevant firms under their membership to participate in the focus group discussions and/or in-depth interviews.

The listing (noted in point 2 above) was to be used to compile a geographic concentration map of firms according to their sector of operation. This mapping allows definition of the scatter of industry sectors across the geographic landscape of Malaysia. This is an important part of the sampling procedure because it provides a balanced view as to how geography will determine the natures of the predominant industry. Sampling for the focus groups and in-depth interviews is based on the geographic concentration map, allowing us to ensure that the different regions and their industries are better represented in our focus groups and in-depth interviews (refer to **Figure 1.5**).

Figure 1.5: Sample for Qualitative Study Based On Regions in Malaysia



Sector	No of firms
Agriculture	26
Food Processing	11
Biotechnology	11
Chemical, Petroleum, Pharmaceutical	15
Rubber & Plastics	9
Wood base	14
Fabricated metal	4
Automotive	3
Transport Equipment	2
Textile, Apparel & Footwear	10
Electrical & Electronics	3
Machinery & Instrument	4

Sector	No of firms
Education	4
Transportation	5
Finance	7
Tourism	9
Telecommunications	2
Health	5
IT Services	10
Business Services	10
Wholesale or retail trade	11
Construction	5
Government Agency/Body	6
Accommodation	3

From the listing, the researchers selected participant firms which met the criteria for the focus group composition. Representativeness and random sampling is not important in qualitative research; participants are chosen for their ability to provide information for their specific sector or company. For example, if the focus group to be conducted in Penang requires a group which comprises 2 agricultural firms, 2 manufacturing firms and 2 service firms, then the researcher will recruit these types of firms. Any accusations of bias should be considered in this light.

Figure 1.5 provides details of targeted numbers achieved for focus group discussions and in-depth interviews categories by contact listings. Researchers from Monash University Malaysia contacted firms on the listing and invited them to participate in the focus groups or in-depth interviews. When consent is received, focus groups and/or in-depth interviews are scheduled accordingly.

Hands-on training was provided to all the interviewers facilitating the focus group discussions and in-depth interviews. A pilot focus group discussion was conducted in the Klang-valley region. This is to ensure that all the interviewers are ready and prepared to conduct focus group and/or in-depth interviews in order to conduce a constructive session.

The focus groups or in-depth interviews sessions was led by researchers at venues and time convenient to the firm participants. Each team consists of 4-8 individuals. Each session is facilitated by a trained moderator, experienced in running focus group discussions. As per Monash University Malaysia ethics guidelines, participants can choose to withdraw from the interview process at any time they wish should they feel uncomfortable in continuing with the focus group or in-depth interview session. All interviews and focus groups will be closely tracked and monitored by the lead researchers to ensure consistency and quality. The focus group discussion guide is provided in ***Appendix-I.***

Analysis of the focus groups and in-depth interview data proceeded via the qualitative procedure of thematic analysis. Thematic analysis allows identification of major themes emerging from the interviews and focus groups. The themes can be aggregated to a general level, or probed for detailed micro-level insights. This provides an overall picture as well as nuanced understanding of the data. The analysis was executed at three different levels.

- ***Level one analysis*** was at the firm level.
- ***Level two analysis*** was at cross-firm for companies operating in the same sector and/or region. This enabled identification of commonalities at the industry sector level, as well as differences arising from specific firm and regional context.
- ***Level three analysis*** will be cross industry. This will provide an overview of what is happening across the different sectors, by drawing sector specific commonalities and differences.

Running parallel to the thematic analysis was a case study compilation. The firms for the case study would be useful to highlight the key issues and best practices of high performing firms and industries. These case studies are drawn from both local and international firms and industries.

1.3 Quantitative Research Methodology

The second method used in the MYKE III study is a quantitative approach, where a structured survey questionnaire was designed using the MYKE III conceptual framework given in Figure 1.4. The questions in the research instrument were adapted from MYKE-II. However, major modifications were undertaken to ensure the questions captured the complex relationships between K-inputs, K-transformations and K-outputs as outlined in **Figure 1.3**. The modifications included the following:

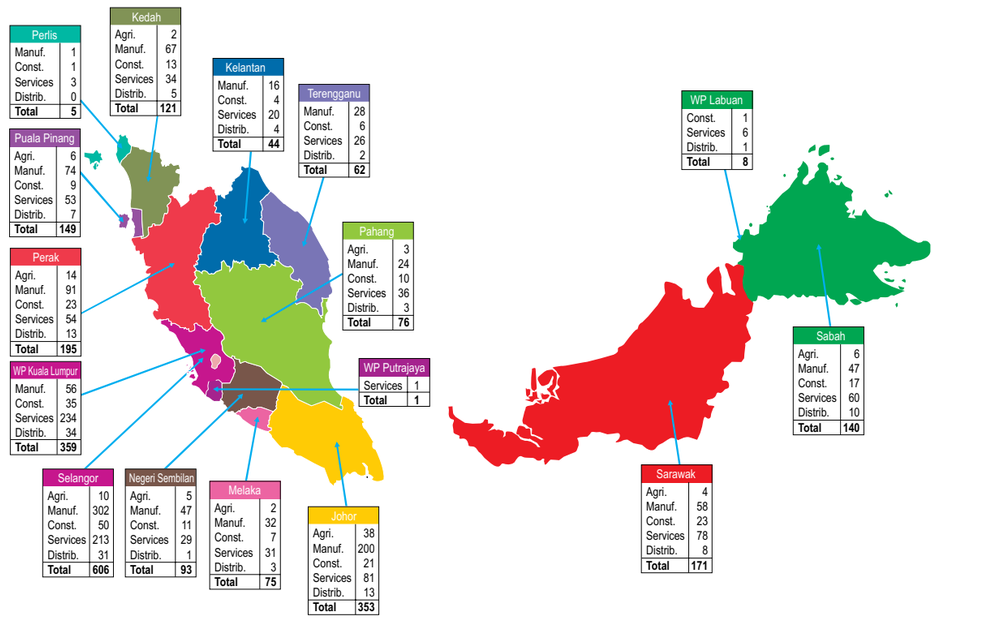
- *Questionnaire Modification 1 (minor modification):* Included new questions for Knowledge Culture (E2).
- *Questionnaire Modification 2 (major modification):* Included new questions for Firm K-Based Capabilities, namely for the following factors, absorptive capability (DC1); adaptive capability (DC2) and innovative capability (DC3). This measure was not included in the MYKE-II questionnaire.
    - *Questionnaire Modification 3 (minor modification):* Included new questions for K-Outcomes, namely for marketing innovations (I4) and new market development (I5).
    - *Questionnaire Modification 4 (major modification):* Included new questions for Economic Outcomes, that is, for the following factors: employment in k-intensive activities (E3); contribution of K-intensive products/ services to exports (E4); and license and patent revenues from abroad (E5).
    - *Questionnaire Modification 5 (minor modification):* Included questions for environmental dynamism (C4).
    - *Questionnaire Modification 6 (major modification):* Included new questions for new moderator called Strategy & Leadership, which entails questions for the following factors: Strategic Posture (SL1); Entrepreneurial Orientation (SL2) and Transformative Leadership (SL3). The measure for Leadership Style was not included in the MYKE-II model.
- *Questionnaire Modification 7* (major modification): Several questions in the MYKE-II used simple scale of "Low, Medium and High". This scale made it difficult to effectively capture the intensity of knowledge content in Malaysian firms. In the new questionnaire, the MYKE-II scales were modified to include a five-point Likert scale, which is widely used in the literature. The new scale provides a better measurement of intensity of knowledge acquisition, transformation and use.

The questionnaire was structured in two parts with the first part capturing the demographic profile of respondent's establishment. The second part captures the respondents' perception on three components which include the level of K-inputs, K-transformation and K-output. The research framework uses a five-point Likert scale with the exception of demographic questions. Respondents are asked to specify the extent of their agreement or disagreement with a variety of statements.

Two sessions with key participants with extensive statistical and sample survey experience from the Economic Planning Unit (EPU) and Department of Statistics Malaysia (DOSM) were invited to evaluate the content validity of the survey instruments. The participants were asked to provide feedback and comments on the clarity and conciseness of questionnaire items. The recommendations of the participants were taken into account and final questionnaire In Bahasa Malaysia and English were completed and sent to DOSM on 28 May, 2014. The final questionnaires in English and Bahasa Malaysia are provided in ***Appendix-II*** and ***Appendix-III,*** respectively.

The sample survey method to obtain the data is based on the MYKE II panel data collected by the Department of Statistics Malaysia (DOSM). The sample consists of 21 industries (shown in Inception Report), with a total of 2,458 firms surveyed using purposive sampling technique. The profile entails 64% of the sample consisting of SME firms; 76% locally-owned; 24% foreign-owned firms; 49% of the surveyed firms are single-establishment firms, and the remaining are multi-establishment firms. The sample was collected from all states and number of firms selected in the respective states is shown in **Figure 1.6.** The profile of firms in the MYKE II and MYKE III are summarised in **Table 1.3.**

Figure 1.6: Sample for Quantitative Study Based on Regions in Malaysia



Note: The sampling and data collection were undertaken by Department of Statistics Malaysia.

Table 1.3: Profile of Firms for MYKE I, MYKE II and MYKE III

Sector Code	Industry	MYKE I, MYKE II & MYKE III																					
		Total Sample			Type of Firm									Location of HQ						Exporters			
					Single Establisment			Multi-establisment			SME			Domestic			Foreign			Yes			No		
		MYKE I	MYKE II	MYKE III	MYKE I	MYKE II	MYKE III	MYKE I	MYKE II	MYKE III	MYKE I	MYKE II	MYKE III	MYKE I	MYKE II	MYKE III	MYKE I	MYKE II	MYKE III	MYKE I	MYKE II	MYKE III	MYKE I	MYKE II	MYKE III
S00	Agriculture	-	99	88	66	65	34	23	-	85	75	-	14	13	-	30	23	-	4	0	-	34	23	25	18	74	70
	Manufacturing	1111	1140	1008	497	473	643	535	745	590	546	366	550	462	921	413	337	190	230	197	1111	643	534	690	587	450	421
S01	Food	139	174	157	72	62	102	95	72	103	90	67	71	67	132	89	84	7	13	11	139	102	95	62	60	112	97
S02	Chemicals	108	116	100	34	28	82	72	55	59	49	53	57	51	73	43	47	35	39	26	108	82	73	83	64	33	36
S03	Rubber & Plastic	133	158	148	69	75	89	73	98	78	77	35	80	71	113	58	41	20	31	32	133	89	73	105	103	52	45
S04	Wood	127	123	102	79	75	44	27	104	69	75	23	54	27	126	38	23	1	6	4	127	44	27	75	51	47	51
S05	Fabricated Metals	118	127	139	57	72	70	67	80	70	81	38	57	58	94	46	40	24	24	27	118	70	67	74	80	53	59
S06	Automotive	82	68	69	20	21	48	48	48	30	22	34	38	47	74	37	38	8	11	11	82	48	49	39	44	29	25
S07	Transport Equipment	67	57	40	32	19	25	21	50	25	22	17	32	18	63	19	15	4	6	6	67	25	21	25	19	32	21
S08	Textile	111	103	76	57	48	46	28	89	53	48	22	50	28	98	35	21	13	11	6	111	46	27	63	34	40	42
S09	Electrical & Electronics	120	123	125	35	48	88	77	76	54	49	44	69	76	79	33	21	41	55	54	120	88	75	93	98	30	27
S10	Machinery	106	91	52	42	25	49	27	73	49	33	33	42	19	69	15	7	37	34	20	106	49	27	69	34	22	18
	Services	673	902	909	470	550	432	359	353	630	672	320	272	237	633	378	318	40	54	41	673	432	359	82	230	820	679
S11	Tertiary Education	66	73	58	37	33	36	25	45	48	37	21	25	21	64	32	23	2	4	2	66	36	25	6	18	67	430
S12	Transportation	123	202	192	119	124	83	68	58	149	152	65	65	53	40	118	77	60	5	6	9	123	83	69	15	39	187	153
S13	Finance	59	15	23	1	4	14	19	8	3	14	51	12	9	52	14	16	7	0	3	59	14	19	1	6	14	17
S14	Tourism	132	166	165	77	84	89	81	77	92	98	55	74	67	127	79	73	5	10	8	132	89	81	4	78	162	87
S15	Telecommunication	41	40	30	3	7	37	23	11	11	10	30	29	20	38	35	22	3	2	1	41	37	23	9	16	31	14
S16	Health	91	96	122	56	83	40	29	59	62	89	32	34	33	89	39	39	2	1	0	91	40	39	9	22	87	100
S17	Information Technology	72	74	66	29	22	54	44	33	57	41	39	17	25	58	34	33	14	20	11	72	54	44	23	29	51	37
S18	Business	89	236	253	157	193	79	60	62	2208	231	27	28	22	87	68	52	2	11	7	89	79	59	15	22	221	231
S19	Retail Trade	-	55	124	21	80	34	44	-	46	102	-	9	22	-	29	34	-	5	9	-	34	43	0	18	55	106
S20	Construction	-	237	217	182	180	55	37	-	201	187	-	36	30	-	54	36	-	1	2	-	55	38	6	10	231	207
	Total Number of Firms	**1784**	**2433**	**2458**	**1235**	**1348**	**1198**	**998**	**1098**	**1552**	**1582**	**686**	**881**	**764**	**1554**	**904**	**748**	**230**	**294**	**249**	**1784**	**1198**	**997**	**803**	**863**	**1630**	**1483**

Notes

1. Multi-establishment firms refer to firms that have two or more establishments
2. Small-and medium-sized enterprises (SMEs) are defined as firms with less than 100 employees
3. A firm is considered domestic-oriented if its headquarters is located in Malaysia and is foreign if otherwise
4. A firm is considered exporter if it exported its output in 2005 (MYKEII) and 2013 (MYKEIII)
5. From sample size of 2458, only 2346 data are valid.

1.4 Organisation of the Report

The organisation of the report is outlined below. From Chapters 2 to 22, a detailed analysis of knowledge content for each of the 21 industries is discussed. These chapters provide the following: an overview of the state of play of the industries, including key developments and initiatives; evaluations of knowledge content of the industries, including the knowledge enablers (human capabilities, knowledge systems & leadership, technology and infostructure and knowledge environment) and knowledge actions (knowledge generation, knowledge sharing and knowledge utilisation); assessment of the industries dynamic capability, which include absorptive capability, adaptive capability, innovative capability; and outcomes of dynamic capabilities (market presence and strategic profile of the firms).

These chapters also examine the complex relationships between knowledge inputs, knowledge transformation and knowledge outputs (see **Figure 1.4**) using the MYKE III data. The impact analysis provides insights on the factors that encourage and hinder knowledge acquisition, absorption and value creation among Malaysian firms. In this chapter, the Partial least squares (PLS), a component-based Structural Equations Model (SEM) methodology is used to evaluate the inter-relationships between the key factors that impact dynamic capabilities and its impact on performance of firms. The multivariate statistical technique used in this chapter specify the relationships between factors that lead to increasing knowledge content among firms in the 21 industries; and the key factors that impact the translation of dynamic capability to economic outcomes of the firms in the respective industries. The industry level analysis provides valuable insights on why some industries are unable to close the knowledge-wealth gap. Key policies and best practices are identified to assist industries in different stages of development to move up the knowledge and innovation value chain.

In Chapter 23, a macroeconomic perspective of the Malaysian knowledge economy based on the quantitative and qualitative analysis of the 21 industries is provided. The chapter also examine the inter-linkages and knowledge flows between the industries. Information on inter-linkages and knowledge flows between industries will inform the key industries (known as *'Enabling Industries'*) that assist other industries to enhance their dynamic capabilities and economic outcomes. The knowledge ecosystems for the 21 industries will be aggregated to represent the knowledge ecosystem of Malaysia. The knowledge content and innovation of Malaysia will be benchmarked with that of more developed countries. Based on this aggregated analysis, key strengths, challenges and macro-level strategies will be identified to enable Malaysia to 'leap-frog' to a knowledge-intensive and high-income economy. The final chapter also outlines some of the caveats to the MYKE-III (Phase 1) study and proposes ways to improve the study for the MYKE-III (Phase 2) study.

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CHAPTER 2

KNOWLEDGE CONTENT OF THE AGRICULTURE INDUSTRY

CHAPTER 2
Knowledge Content of the Agriculture Industry

2.0 Introduction

The competitiveness of the Malaysian agriculture industry is important to safeguard the nation's food security, and for this industry to be a major contributor to the Malaysian economy in terms of creating employment and as a source of national income. In 2014, agriculture contributed 9.2% to the nation's GDP, including the sub-industries that comprise oil palm, rubber, cocoa, paddy, fisheries, livestock and other agriculture products (Department of Statistics Malaysia, 2015). The agriculture industry supports the home market, and contributes significantly to the nation's exports. In 2014, export earnings from commodities and commodity products amounted to RM116.6 billion, or 15.22% of the total export earnings of the country (Ministry of Plantation Industries and Commodities, [MPIC], 2015). Exports of agricultural goods reached RM69.2 billion in 2014, while palm oil exports grew by 2.3% to RM46.95 billion, accompanied by a 3.6% growth in average unit price, and 5.3% in quantity. In contrast, exports of crude natural rubber declined by 34.9% to RM4.57 billion, due to a 23.6% drop in average unit price and 14.8% reduction in export quantity (MITI Report 2014).

The industry remains labour-intensive and provides subsistence-level employment. There is an increasing trend towards employing foreign labourers to work in the agriculture industry – this is evidenced by the numbers, showing that the number of foreign labourers increased by 35.3% from 2012 to 2013 (Department of Statistics Malaysia, 2014). The industry is predominantly production-centric, with weak links to the market. Farmers rely heavily on traders or middlemen to get output to end markets. Additionally, Malaysian agriculture is primarily centred on commoditised products of low value in the marketplace. Only a minor level of activity involves higher value products, such as herbs (National Key Economic Areas [NKEA], n.d).

Rubber, palm oil and cocoa plantations are mainly owned by private companies, public-listed corporate entities or part of public land development agencies in the form of "estate" holdings. A single estate unit is normally large, commonly ranging between 2,000 to 10,000 hectares. In contrast, independent smallholdings are limited to being between 1 to 2 hectares, and are normally managed by family households (Barlow, 2012). The production of food crops, such as fruits and vegetables, is dominated mostly by private, small-scale farmers, and lacks the presence of large industrial-scale production (NKEA, n.d).

The paper will now examine growth in the main sub-sectors.

Rubber

Over the years, the volume of natural rubber production decreased, even though the rubber based downstream industry remains a major contributor to the Malaysian economy. In fact, natural rubber production decreased by 19.1% between 2013 and 2014 (Department of Statistics Malaysia, 2015). Nonetheless, rubber products made up 2.4% (RM18 billion) of Malaysia's total export in 2014, (Malaysia External Trade Development Corporation [MATRADE], 2014). The decrease in agricultural output is contrasted by growing activity in the processing and manufacturing of rubber-related products. The shortfall in output is filled by growing import of natural and synthetic rubber.

Rubber has many end-uses. Rubber products industry can be categorised into latex, tire-related products, industrial use, and general rubber products. Latex products include rubber gloves, catheters, latex thread, condoms and foam products. To date, Malaysia is the world's largest exporter of rubber gloves with it contributing an average of RM6 billion to annual GDP. Major natural rubber export destination includes China, Germany, South Korea, USA, Iran, France, Brazil and Netherlands (Shahid, 2012).

Demand for rubber in the global market remains robust. According to an IMF scenario based forecast, the world's total rubber demand is likely to increase by 1.8% and 4.1% in 2015 and 2016 respectively, reaching 29.1 million tonnes in 2015 and 30.3 million tonnes in 2016 (International Rubber Study Group, 2015). Specifically, the demand for natural rubber is predicted to be 12.9 million tonnes in 2016, increasing to 16.5 million tonnes by 2023 whereas the demand of synthetic rubber will rise to 17.5 million tonnes and reach 21.5 million tonnes by 2023 (Rubber Journal Asia, 2015).

Palm Oil

Being an export-oriented agriculture commodity, Malaysia currently contributes to 39% of global palm oil production and 44% of world exports (Malaysian Palm Oil Council [MPOC], 2016). Performance of the industry moves in accordance to changes in world supply and demand conditions. Palm oil and palm-based products currently accounts for 7.8% of total exports, underscoring its importance to the economy as revenue increased from RM263.5 million to RM4.8 billion (Department of Statistics Malaysia, 2016). Indonesia and Malaysia together produce about 85% of the world's palm oil. Major palm-based products export destinations include USA, EU, Pakistan, Japan, China, India, Middle East and Northern Africa (Shahid, 2012).

Over 60% of the total planted area is under private ownership, the majority of which is owned by large plantation companies with integrated operations covering the entire production process, from cultivation to the refining and manufacturing of consumer products. Of the remaining, 24.8% of the planted area is under Government land schemes, such as FELDA, and FELCRA, and 13.6% belongs to individual smallholders. Most large plantation companies operate their own nurseries, while smallholders obtain seedlings from licensed nurseries. There is a total of 602 licensed nurseries and 23 seeds producers in the country. Sarawak has the highest number of nurseries (150) followed by Johor (113). Johor and Sarawak have the highest number of seeds producers with 9 and 7 seed producers respectively.

Others Agricultural Activities

Cultivation of rice, the country's major food crop, increased by 41.0 thousand tonnes (1.6%) in 2014 as compared to 2013 (Department of Statistics Malaysia, 2015). However, this level is only sufficient to meet about 65% of the domestic need. The remaining 35% is imported from neighbouring countries such as Thailand and Vietnam. Padi Beras National Berhad (Bernas) is the sole importer of rice, and is able to do so duty-free.

The Malaysian horticultural industry supplies fresh fruit and vegetables to the population. Malaysia is a net importer for vegetables. In 2013, exports of vegetables and fruits amounted to RM594.6 million, while imports of vegetables and fruits, such as apples, grapes and oranges, amounted to RM2.5 billion (Malaysia Investment Development Authority [MIDA], 2013).

The production of cocoa beans, copra and spices noted a decrease of 3.6% in 2014 as compared to 2013 (Department of Statistics Malaysia, 2015).

The Malaysian Agricultural Research and Development Institute (MARDI) recorded gross profits of more than RM5.4 billion per annum from herbal related products (Ahmad & Othman, 2013). Herbal products have high growth potential in Malaysia owing to the local tropical climate, and diversity of flora (particularly those with medicinal properties). In Malaysia, more than 2000 plant species are considered to have curative qualities and thus present high potential to be commercialised.

As for the fisheries industry, marine fish landings increased by 0.5% from 2012 to 2013. Perak recorded the highest marine fish landings (20.8%), followed by Sabah (12.8%) and Sarawak (10.9%). Supplementing this supply is the aquaculture industry. This is one of the fastest growing segments in Malaysia's fisheries sub-industry, with an estimated annual production of 300,000 metric tonnes. In 2013, Perak was the highest producer of freshwater aquaculture while the highest producer of brackish water aquaculture was Sabah(Department of Statistics Malaysia, 2014). Malaysia's total exports of fish and other seafood in 2013 amounted to RM1.8 billion while imports amounted to RM2.6 billion (MIDA, 2013).

2.1 Key Developments and Initiatives

A number of bodies and initiatives have played a key role in driving the development of the agriculture industry. The Ministry of Plantation Industries and Commodities (MPIC) is responsible for commodities, including rubber, palm oil, cocoa, forestry, minerals, pineapple, pepper and tobacco. The Ministry of Agriculture and Agro-Based Industry (MOA) oversees crop production, livestock and fisheries activities. Through these bodies, the National Agricultural Policies (NAP) was introduced to develop and elevate the domestic agriculture industry to compete globally. Consequently, the government invested heavily into infrastructure, advanced technologies and machinery to overcome low productivity, especially among smallholders and farmers.

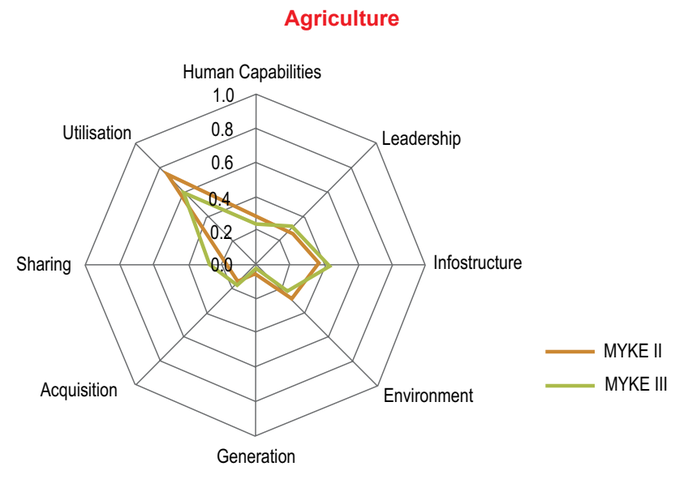
In its early steps to support agriculture, the government established Kolej Serdang, which was renamed 'Agriculture University of Malaysia' in the 1970s, and is presently known as 'Universiti Putra Malaysia' (UPM). The institution's goal is to train agriculture and agro-industrial engineers as well as agro-business graduates to become qualified field researchers. In recent times the focus of UPM has somewhat diversified away from its specialist origin. Similar supportive measures have been taken in other sub-industries of agriculture. In 1979, the Palm Oil Research Institute of Malaysia (PORIM) was established. In 2000, the Malaysian Palm Oil Board (MPOB) was established following the merger of the Palm Oil Research Institute of Malaysia (PORIM) and the Palm Oil Registration and Licensing Authority (PORLA). Its principal objectives are to conduct and promote research and development in oil palm breeding, palm oil nutrition and potential oleo-chemical use. MPOB is funded by both the public and private sectors in a coordinated effort to create the nation's top research entity. "MPOB is committed to assisting the industry to maximise productivity and production, increase product range, introduce new technologies and create opportunities for the Malaysian palm oil industry." (Sime Darby Plantation, 2014)

2.2 Knowledge Content

The sample used to map the knowledge ecosystem for the Malaysian agriculture sector was based on the following samples for MYKE-II and MYKE-III studies, respectively: 99 and 88, as shown in **Table 1.2**. The agriculture sector was not included in the MYKE-I study. The number of SMEs and large players for the two sample periods were as follows: (SME, Large) are (85, 14) and (75, 13), respectively.

An evaluation of the performance of the agriculture industry in terms of its knowledge resource foundations in the period 2007 to 2014 allows an interesting picture to emerge. The agriculture industry demonstrates general weakness almost across all knowledge elements (see **Figure 2.1**)

Figure 2.1: Overview of Knowledge Enablers and Knowledge Actions for MYKE II and III



Note: The agriculture industry was not included in the MYKE I study.

Despite progress in some areas between 2007 and 2014, overall performances remained weak and below Malaysian industry average, except for knowledge utilisation which is on par with Malaysian industry aggregate (refer to **Figure 2.2** to **Figure 2.8**). Any change observed was mostly marginal, except for knowledge sharing and utilisation. Overall, firms in agriculture industry improved in terms of sharing knowledge but appear weakened in terms of the effectiveness of making use of acquired knowledge.

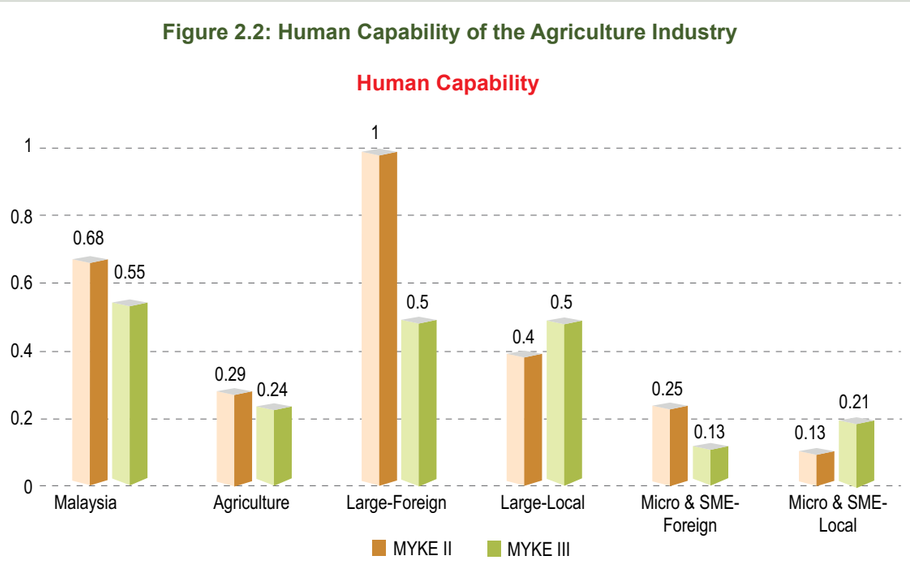
2.3 Knowledge Enablers

2.3.1 Human Capabilities

In terms of human capability, both large and small local firms are gradually getting better over time. They are becoming more active and involved in recruiting higher calibre individuals as well as providing training for existing staff. The industry is taking tentative steps to recruit capable people into what is often perceived to be an unattractive industry in terms of pay and working environment. However, relative to other industries, the capability gap remains large and requires significant additional steps to attract and retain human resources. The agriculture industry score (0.24) is significantly below the national baseline (0.55) (**see Figure 2.2**).

Although more degree holders have entered the agriculture industry over time, the industry still struggles to find employees with relevant agricultural and/or horticultural knowledge and qualifications. Most graduates from Malaysian universities are generalists, lacking specialised agriculture-related knowledge, they also lack practical experience on the ground.

Figure 2.2: Human Capability of the Agriculture Industry

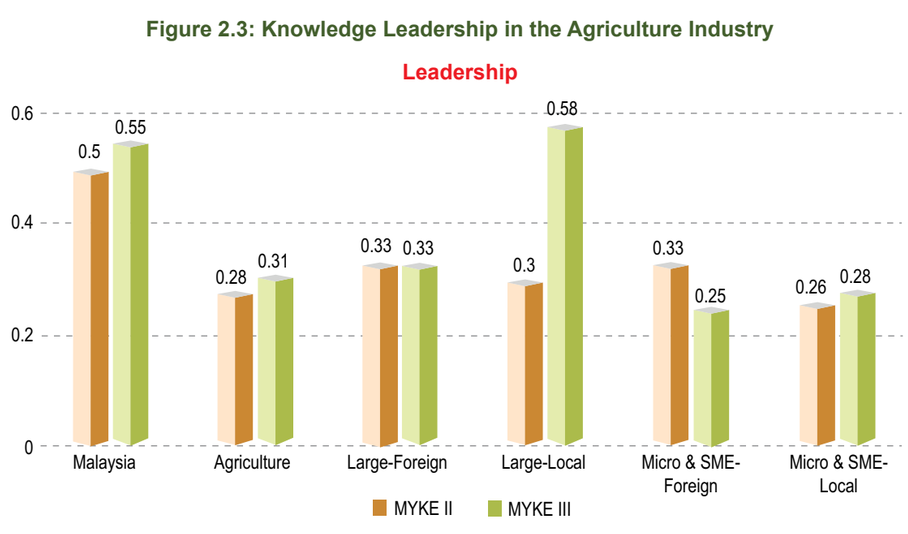


Note: Number of foreign (large and SMEs) agriculture firms in the sample are low, and hence caution must be taken in interpreting figures comparisons of these groups.

2.3.2 Knowledge Systems and Leadership

The agriculture industry (0.31) performs below Malaysian industry aggregate (0.55) in terms of knowledge-leadership (see **Figure 2.3**). Even though there is some improvement between 2007 and 2014, that improvement is only marginal. The industry continues to struggle in its approach to management of knowledge, especially its formalisation within processes and structures. This problem is especially prevalent among small establishments, which have limited resources and capabilities to standardise their processes and document their operational knowledge. As such, knowledge development is rarely systemised in the agriculture industry, especially among micro and SMEs players.

Figure 2.3: Knowledge Leadership in the Agriculture Industry



Note: Number of foreign (large and SMEs) agriculture firms in the sample are low, and hence caution must be taken in interpreting figures comparisons of these groups.

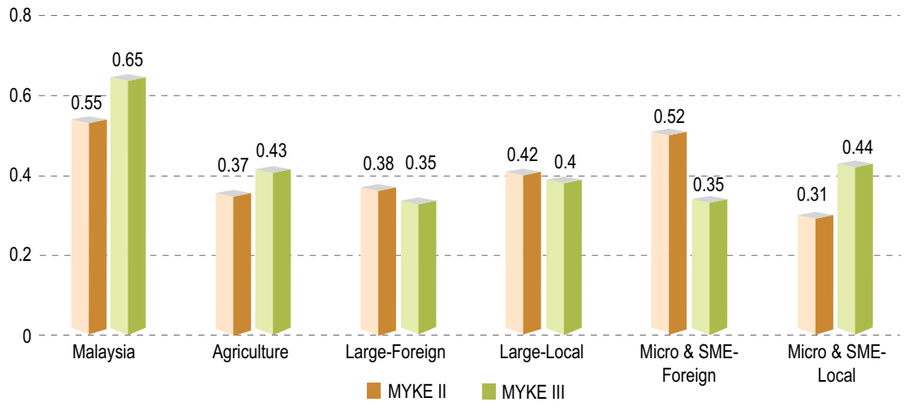
2.3.3 Technology and Infostructure

In terms of ICT and use of basic technology, such as personal computers in the workplace, the agriculture industry shows some improvement. The infostructure score of Malaysia's agriculture industry increased from 0.37 in 2007 to 0.43 in 2014 (see **Figure 2.4**). However, the infostructure score of the agriculture industry is considerably lower than the Malaysia Industry aggregate, indicating that the industry lags behind in terms of technology use.

2.3.4 Knowledge Environment

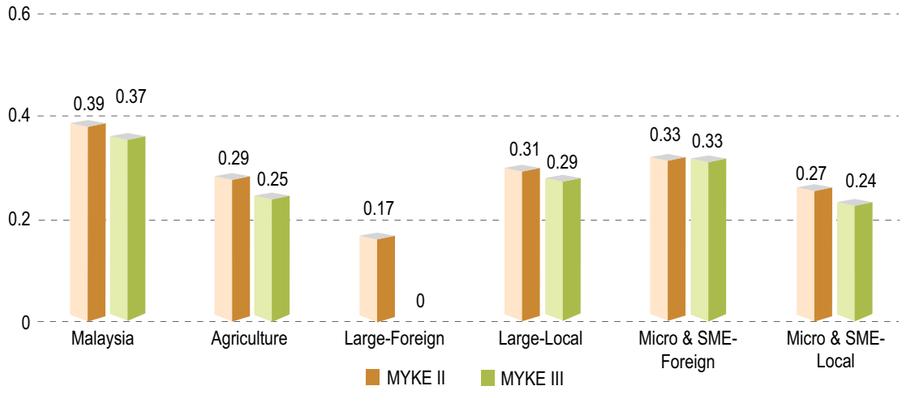
The agriculture industry exhibits a low level of engagement with support institutions such as government agencies and industry associations. This is rather surprising given the level of targeted provisions created by the institutions herewith to enhance the industry's capabilities. Moreover, the small and micro-organisations that are the most direct targets of these provisions yielded the lowest scores. One of the reasons underlying the poor level of engagement is that many micro and small agriculture firms are focused on basic business continuity and have little inclination to build new capabilities or networks in industry associations.

Figure 2.4: Technology and Infostructure of the Agriculture Industry



Note: Number of foreign (large and SMEs) agriculture firms in the sample are low, and hence caution must be taken in interpreting figures comparisons of these groups.

Figure 2.5: General Environment Awareness of the Agriculture Industry



Note: Number of foreign (large and SMEs) agriculture firms in the sample are low, and hence caution must be taken in interpreting figures comparisons of these groups.

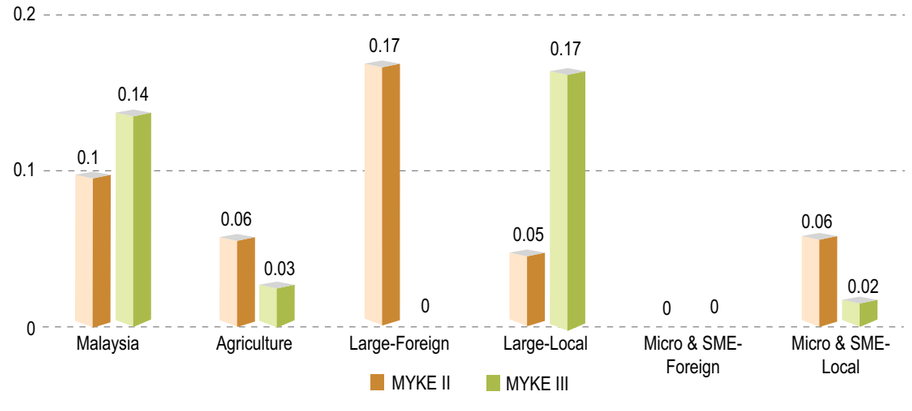
2.4 Knowledge Actions

2.4.1 Knowledge Generation

There is hardly any knowledge generation in Malaysia agriculture industry. This is reflected in the dismal score of knowledge generation in 2007 (0.06) and in 2014 (0.03) (see **Figure 2.6**). Unlike most elements of knowledge enablers and actions that have at least progressed minimally over time, knowledge generation in the agriculture industry has materially declined.

R&D and patent-filing activities are clearly not taking place within the agriculture industry. Even where R&D is conducted, it is mainly within government-related research institutions or by large multinational firms who are better endowed in financial resources as well as human expertise. Small players, who make up the majority of firms in the agriculture industry, are simply beneficiaries of the innovations and research by others. The main focus is identifying seed varieties and technology to improve yield. In horticulture and other crop agriculture industries, local players rely mainly on international breeders to develop new species. What few research activities conducted within the industry are mostly to determine which breeds perform best in Malaysia's climate and localised ecospheres.

Figure 2.6: Knowledge Generation Activity in the Agriculture Industry



Note: Number of foreign (large and SMEs) agriculture firms in the sample are low, and hence caution must be taken in interpreting figures comparisons of these groups.

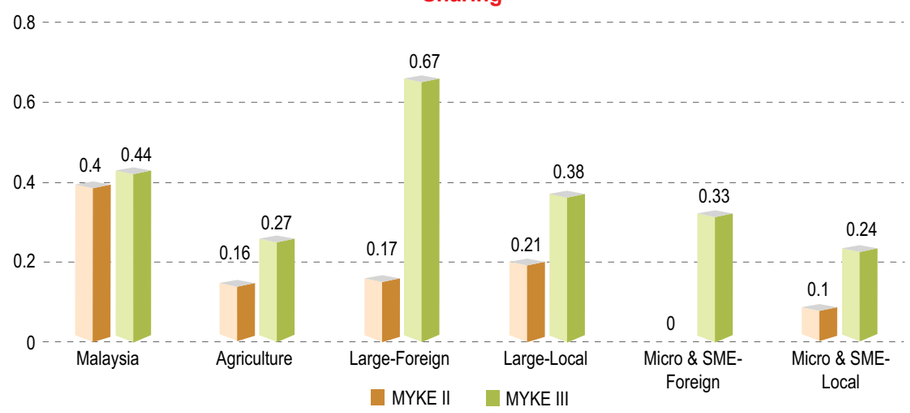
2.4.2 Knowledge Sharing

Knowledge sharing in the agriculture industry improved from 0.16 in 2007 to 0.27 in 2014 (see **Figure 2.7**). A similar progress is observed across the different categories of firms, though the highest level of sharing arises from large multinational firms. This is unsurprising since the largest firms (most of them foreign) supply their local counterparts. Nonetheless, positive indicators are being demonstrated by agriculture community, in the form of greater knowledge exchange across the value chain.

2.4.3 Knowledge Utilisation

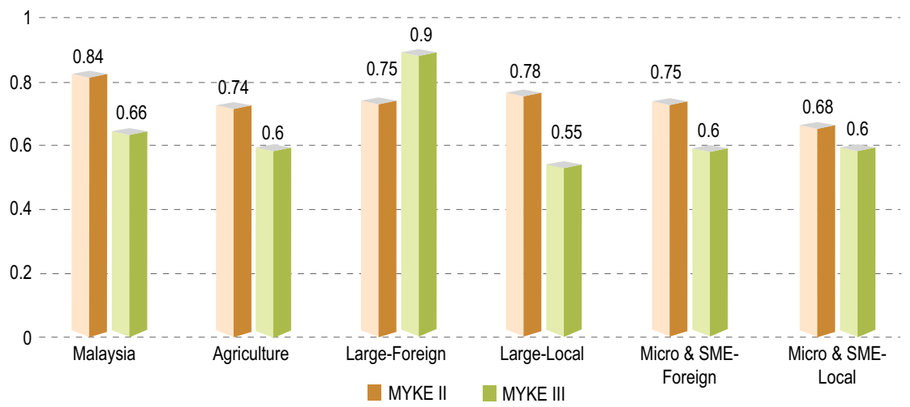
In step with the national aggregate, the agriculture industry also registered a decline in knowledge utilisation (see **Figure 2.8**). However, the industry's performance in knowledge utilisation is the highest among all the different elements of knowledge in the industry (see **Figure 2.1**). Even though agricultural firms are not generating high volumes of new knowledge, they apply the knowledge that they do have in a relatively high capacity. Large foreign firms are the best performers, and have over time improved the effectiveness of their knowledge utilisation compared to their counterparts.

Figure 2.7: Knowledge Sharing Activity of the Agriculture Industry



Note: Number of foreign (large and SMEs) agriculture firms in the sample are low, and hence caution must be taken in interpreting figures comparisons of these groups

Figure 2.8: Knowledge Utilisation Activity of the Agriculture Industry



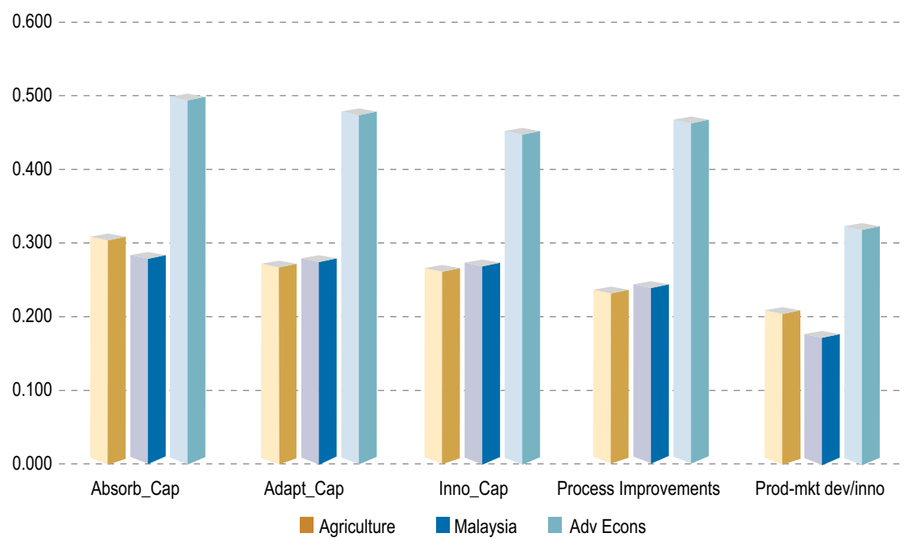
Note: Number of foreign (large and SMEs) agriculture firms in the sample are low, and hence caution must be taken in interpreting figures comparisons of these groups.

2.5 Dynamic Capabilities Profile for Agriculture Industry

The agriculture industry shows a weak overall development of its knowledge resource foundations which firms rely on to generate dynamic capabilities. Dynamic capabilities constitute the ability to adapt to changes in the surrounding environment and turn challenges into competitiveness. Absorptive, adaptive and innovative capabilties are the three main component of dynamic capabilities.

Figure 2.9 shows the agriculture industry's dynamic capability profile and outcomes. Despite its weak knowledge foundation, the agriculture industry outperforms the Malaysian industry aggregate in terms of absorptive capability, but falls slightly short in terms of adaptive and innovative capabilities.

Figure 2.9: Dynamic Capability Profile of the Agriculture Industry



2.5.1 Absorptive Capability

Among the three dynamic capabilities, the agriculture industry scored highest in its absorptive capability. This indicates that agriculture firms scan the market for new opportunities and insights, and also absorb knowledge through the adoption of new technologies. It is often the case that the state-of-the-art machines used in agriculture are not available in Malaysia, and industry players have to source them from overseas. Many of Malaysia's farming techniques and equipment are sourced from developed countries or regionally from Taiwan and even Thailand. Most significantly, Malaysian firms rely on foreign breeders for seeds and new breeds of crops. This is often the crucial 'technology' component in agriculture industries.

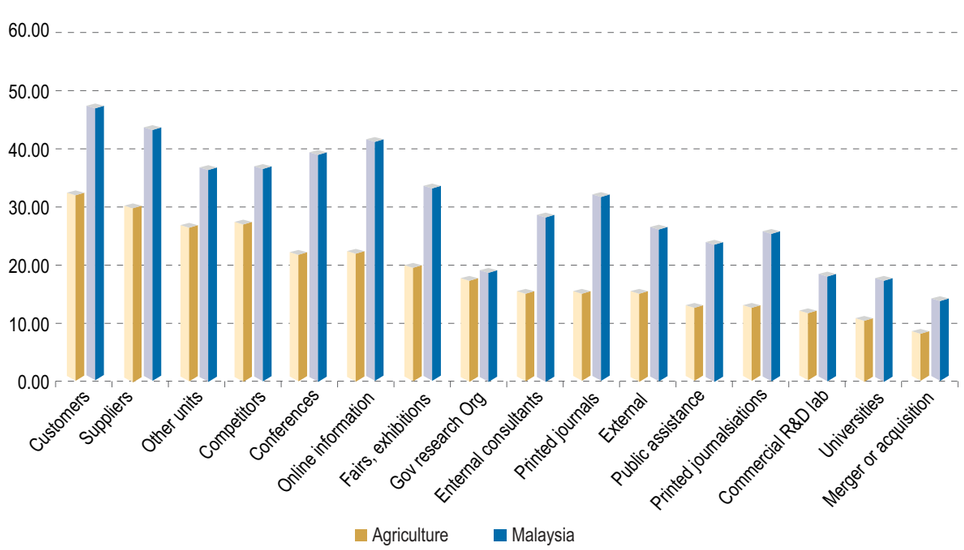
In terms of sources of knowledge (see **Figure 2.10**), the agriculture industry relies mostly on customer feedback, relationships with suppliers, benchmarking competitors and gaining knowledge from different internal units. Many agriculture operations have close links with their suppliers, especially agro-chemical firms who usually provide significant technical information to small holding farmers. However, the industry is very weakly engaged with universities, and little knowledge is exchanged between them.

2.5.2 Adaptive Capability

Gathering knowledge and technology from external sources is an important activity but if the firm is not capable of using it internally, many of the benefits of knowledge are lost. Once information and insights are gathered and technology is acquired, firms must have a sufficient level of adaptive capability to be able to apply such knowledge and technologies internally.

The agriculture industry demonstrates an emerging pattern, where most of the knowledge is concentrated in the hands of a small group of individuals at the top tiers of the organisational hierarchy and not widely disseminated to workers. Additionally, there is a fundamental problem of knowledge dissemination from the bottom to the top. The agriculture industry is heavily dependent on foreign workers, some of whom over time accumulate significant technical knowledge through on-the-job experience; unfortunately, little effort or resources are allocated to knowledge documentation and formalisation. This hinders transfer of knowledge within the firm and also leaves them vulnerable to knowledge drain caused by worker turnovers. Through such weaknesses in internal processes and resource allocations, the adaptive capability of the industry is compromised.

Figure 2.10: Sources of Knowledge in the Agriculture Industry



The skills profile of the agriculture industry shows greater presence of engineering and computer science graduates compared to biotechnology and agriculture science graduates. Only 20.45% of employees have qualifications in agriculture science (see **Figure 2.11**). Strong research and development focused industries should typically have a higher number of field specialists rather than generalists, which currently dominate the agriculture industry in Malaysia.

Building strong capabilities often necessitates support from a range of agencies. The agriculture industry does not appear to be as well-geared in seeking and receiving help as other industries (as shown in **Figure 2.10**). It acquires lower support across most dimensions compared to the Malaysian aggregate. The areas where it does seek assistance are shown in **Figure 2.12**. Many of the firms seek help in improving their quality management processes, and research and commercialisation assistance.

Figure 2.11: Skills Profile of the Agriculture Industry

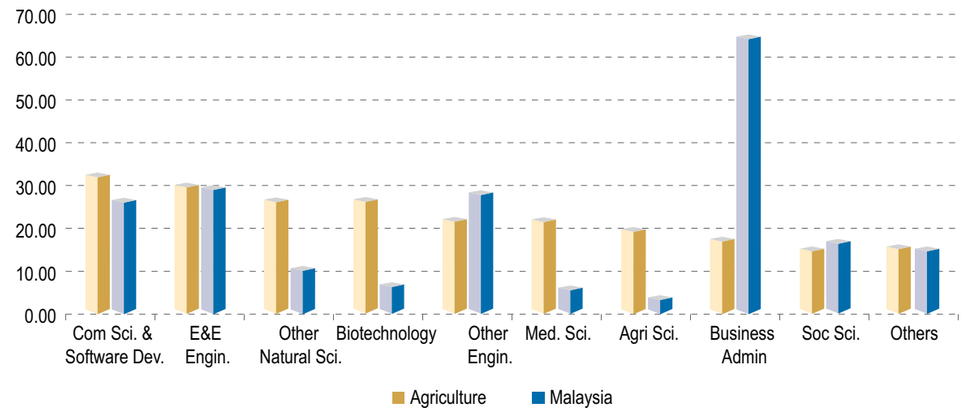
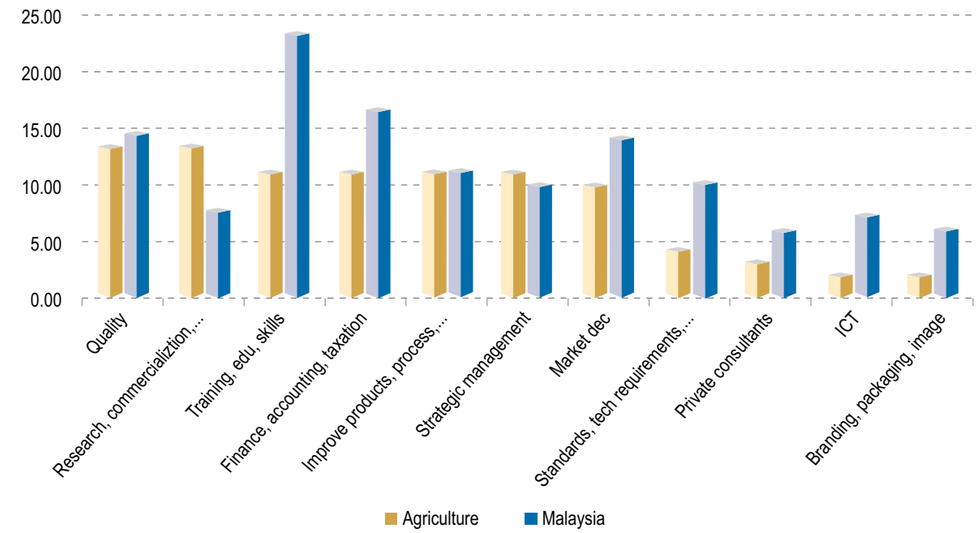


Figure 2.12: Role of Institutional Environment in Skill Building of the Agriculture Industry

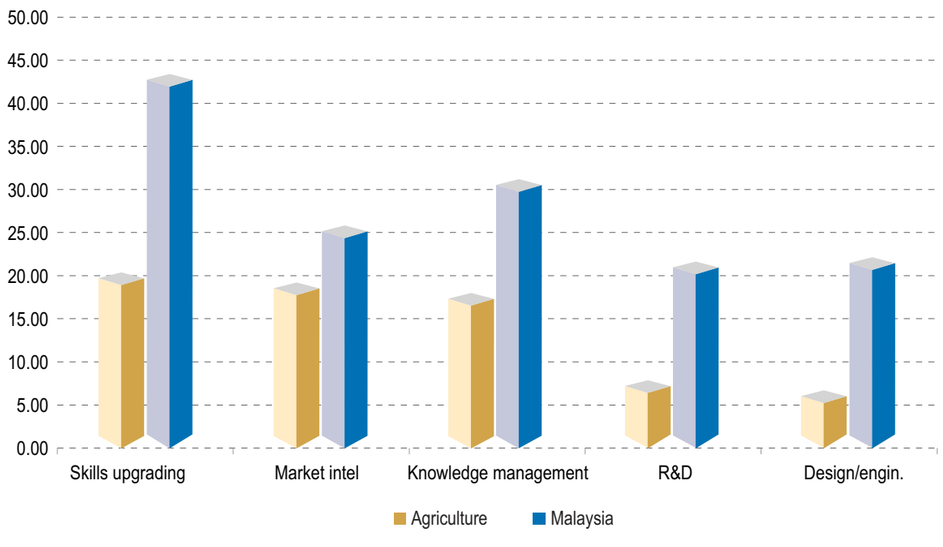


2.5.3 Innovative Capability

It is not enough to simply gather information and acquire technology, firms must be able to assimilate external knowledge within their people and processes in a manner that allows them to create new products and innovations. Malaysia's agriculture industry does not allocate the right type and level of resources to be able to use this knowledge efficiently despite acquiring extensive amount of technologies and knowledge from external sources. In other words, absorbed knowledge remains as general knowledge and fails to be applied contextually within the firm. There is a lack of sufficient resources to respond quickly to new opportunities, which means firms in the industry find it difficult to be innovative. As such, Malaysia's agriculture industry scores slightly below the Malaysia industry aggregate in innovative capability. Even though the industry makes attempt to assimilate external knowledge, without adequate people and structured processes, firms in the industry are unable to react in a timely manner when opportunities arise.

Figure 2.13 shows that the agriculture industry is engaged in very low level of innovation capability building activities. Firms in the industry considerably score below the national aggregate in skills upgrading, developing of market intelligence, knowledge management, R&D and design improvements.

Figure 2.13: Knowledge Intensive Activities in the Agriculture Industry



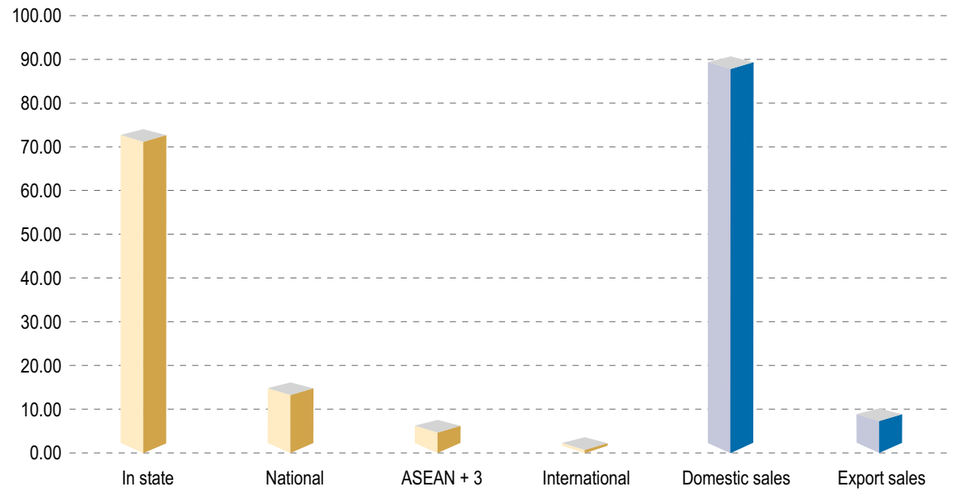
2.6 Outcomes of Dynamic Capabilities in the Agriculture Industry

The agriculture industry is primarily geared to meet the needs of the domestic market, from which it harvests 90.5% of its revenue. Additionally, activity is strongly geographically concentrated with 74.3% of revenue coming from in-state. Some exports to regional markets (ASEAN plus Japan, China and South Korea) take place, accounting for 7.25% of total revenue, with the 1.92% arising from global markets. (see **Figure 2.14**)

One of the problems in the agriculture industry is the prevalence of weak internal processes compared to the Malaysian aggregate, despite efforts to create better marketplace understanding. Weaknesses in operational matters indicate the need to achieve greater cost efficiencies as well as improve effectiveness of management and marketing processes to deliver high value-add in end-products.

Whilst the agriculture industry does not perform badly in product and market outcomes, the caveat is that the firms operate almost exclusively in a captive domestic market with imitative offerings. These are the characteristics of followers, not innovators.

Figure 2.14: Market Presence of the Agriculture Industry



Note: The results are based on survey data.

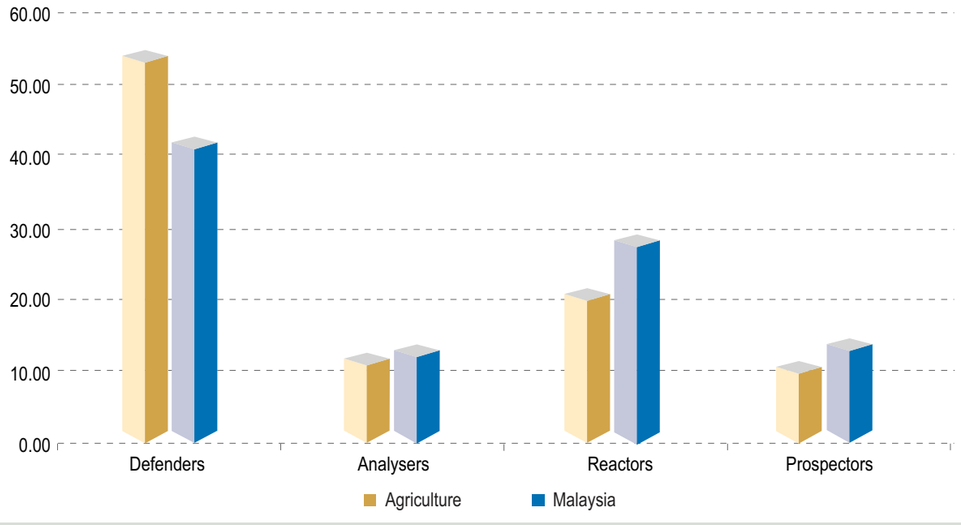
Figure 2.15 shows firms' strategic profile in the agriculture industry. The numbers demonstrate the strong dominance of Defender firms (54.55%). The second largest group is the Reactor type firms (21.59%). The last two groups are Analysers (12.50%) and Prospectors (11.36). Relative to the national aggregate, the agriculture industry has higher percentage of Defenders and lower levels of Reactor, Analyser and Prospector firms. More than half of the firms in the industry are Defenders, suggesting it to be an industry that is focussed on protecting existing products and commodity offerings, rather than developing new and novel lines of agricultural produce through innovation. Analyser and especially Prospector firms are both forward-looking but exist in the smallest number within the agricultural industry. This is a signal of an innovatively inhibited industry.

2.7 Relationships between the Key Blueprints of the Agriculture Knowledge Ecosystem

In this section, we discuss the relationship between the knowledge enablers, dynamic capabilities and economic outcomes for the agriculture industry. The Malaysian agriculture knowledge ecosystem is benchmarked against their counterparts in advanced countries (Australia, Canada, Netherlands and United States). Based on content analysis of these four countries and the data obtained from the DOS for the Malaysian agriculture industry; the Malaysian agriculture knowledge ecosystem was benchmarked against the agriculture industries from these advanced countries. The Malaysian agriculture industry was rated as laggard in terms of knowledge content.

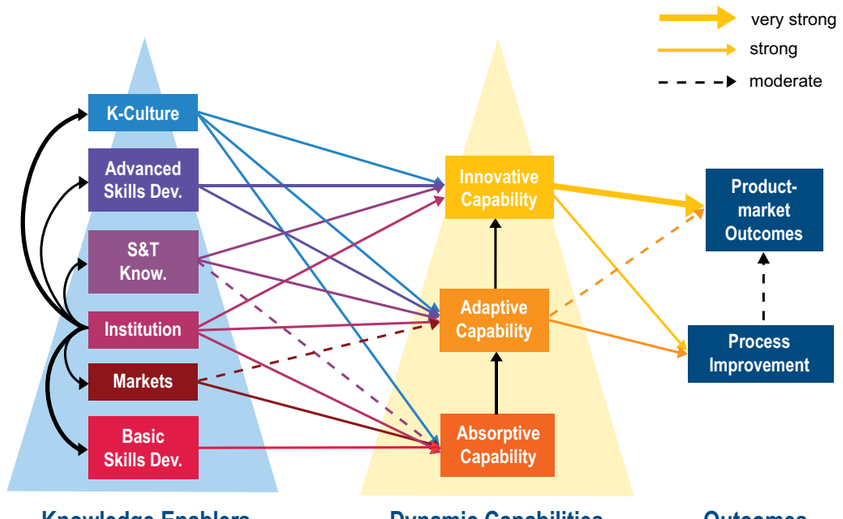
In **Figure 2.16**, the agriculture knowledge ecosystem in advanced countries is shown. In these countries, the enablers for all three components of the dynamic capability are very strong. A very strong absorbing capability in this industry is a good foundation for both adaptive and innovative capabilities for the industries. Sound absorptive, adaptive and innovative capabilities have enabled the industry to develop new process improvements and generate new product outcomes. From these emerge a number of agriculture down-stream industries that are global players.

Figure 2.15: Strategic Profile of Firms in the Agriculture Industry



The agriculture knowledge ecosystem for Malaysia is shown in **Figure 2.17** and it is classified as a laggard industry with low knowledge content. The Malaysian agriculture knowledge system shows that enablers to support the three dynamic capability components are relatively weak and are primarily to enhance process improvement. A summary of the strength of the agriculture ecosystems in advanced countries and in Malaysia is given in **Table 2.1**.

Figure 2.16: Knowledge Ecosystem of the Agriculture Industry in an Advanced Country



Note: Very strong impact are represented by the bolded line, strong impact are represented by normal lines and moderate impact are represented by dotted lines.

Figure 2.17: Knowledge Ecosystem of Agriculture Industry in Malaysia

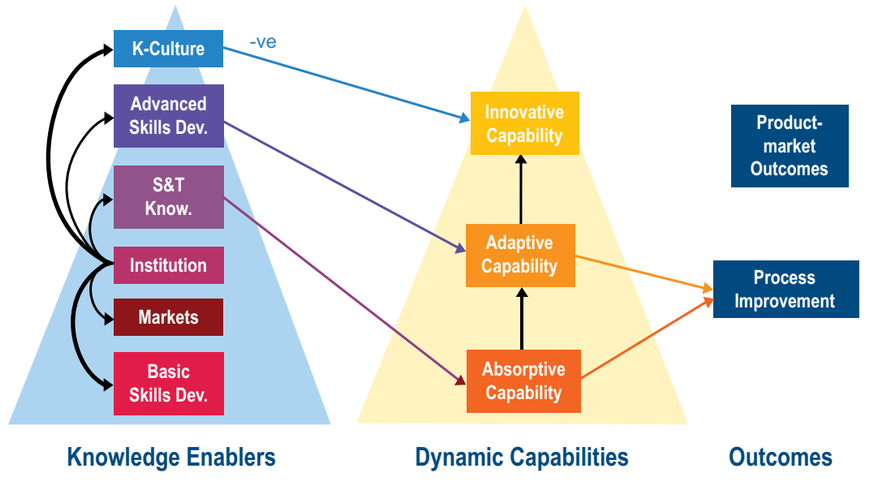


Table 2.1: Knowledge Enablers and Dynamic Capabilities for the Agriculture Industry

Advanced Countries	Malaysia
Basic Skills has a **positive and strong** impact on absorptive capability. In most developed countries where agriculture is an important source of revenue, farmers are provided various resources to continuously improve their basic knowledge via community colleges, technical colleges, polytechnics and universities. The agriculture industry is also reasonably technological and knowledge intensive driven; and is continuously developed. Due to rapid technological and scientific development in the field, the farmers are kept abreast with these new developments via the colleges, polytechnics, government agencies and industry associations. Farmers receive regular training in using the most advanced technology and knowledge to be productive and globally competitive.	Basic Skills has **no significant impact** on any of the dynamic capability components. The Malaysian agriculture industry is very labour intensive and employs transient, foreign labour from neighbouring countries. As such, very little resources are invested into training these workers. The competitiveness of the industry hinges on cheap labour cost.
Market Intelligence has a **positive and strong impact** on absorptive capability; and **positive and moderate impact** on adaptive capability. Suppliers, customers, competitors, external consultants, R&D centres and logistic supply chain are important partners that enhance absorption and adaptation of new knowledge, technology, systems and processes to ensure productivity and efficiency are key drivers for both the upstream and downstream industries in this industry. Significant investment in R&D by both public and private institutions, coupled with sound Intellectual Property (IP) regulations, have led to major scientific and technological breakthroughs that are widely accessible by all levels of the agriculture communities. Widespread use of ICT among farmers keeps them abreast of market conditions, new technology, innovations and scientific discoveries that will enhance their productivity and efficiency.	Market Intelligence has **no significant impact** on any of the dynamic capabilities. The interactions among the key stakeholders are patchy and fragmented. In many instances, the partnerships are dominated by monopolistic behaviour that perpetuate a 'lock-in' effect that prevents farmers from getting the best technology, knowledge or innovations. The use of ICT and new technology is relatively low and industry is plagued by intermediaries and 'rent-seeking' behaviour.

Table 2.1: Knowledge Enablers and Dynamic Capabilities for the Agriculture Industry (cont'd)

Advanced Countries	Malaysia
Institutions are **strong enablers** of the knowledge ecosystem and have a **strong and positive direct impact** on all three dynamic capability components. Both the federal, state and local governments in many of the sample countries ensure that the agriculture cluster is well connected to other key institutions that directly and indirectly that enhance the productivity, efficiency and market reach of the farmers. Incentives (both fiscal and non-fiscal) are provided to government research institutions (GRI), universities, regulators and trade associations play a key role in shaping the agriculture ecosystem and directly influencing the dynamic capabilities components. For example, universities, industry and government agencies work closely to establish strong R&D centres of excellence to undertake leading edge discoveries in better genetically modified seeds, harvesting technology, supply chain and other innovations that contribute to raising the productivity of both the upstream and downstream industries. In many of these countries there are dedicated universities that are focussed in training the next generations of scientists, technologists and entrepreneurs in the agriculture field. Incentives are also in place for leading scientists and students to spawned new 'start-up' enterprises that will contribute to raising the dynamic capabilities of the industry. There are also very strong linkages between the upstream and downstream industry, in particular between the farming communities, food manufacturing industries and the retailers. The supply chain systems are well integrated that fosters seamless integration products from farm lands to retail shops.	Institutions have a **strong impact on the enablers,** but **do not impact** the three dynamic capability components directly. Key institutions such as the regulators, trade association, universities and government agencies play key roles to ensure the development of the agriculture ecosystem. This was clearly evidenced by our establishing of the number of government agencies set up to support the agriculture industry, including FAMA and MARDI. However, these institutions' roles in directly affecting the dynamic capability components were found not to be significant. A number of challenges were identified that hindered dynamic capability components. First, there is no dedicated university or centre of excellence that focuses on a holistic development of agriculture research of global standing; given Malaysia agriculture is a major sector of the economy. Second, while there is considerable R&D taking place in a number of GRIs and universities, access to these discoveries to industry, especially to the SMEs are limited. Third, the poor promotion of agriculture as the preferred choice of employment has led to the best talent in the field going to other disciplines– this has a direct impact on the dynamic capabilities components of the industry. Fourth, the supply networks and the linkages between the upstream (farmers) and downstream industries are weak. Fifth, strong supply networks are in some subsectors dominated by intermediaries. Sixth, the linkages between farmers and food based manufactured industries are rather patchy. Many of the bigger industries either vertically integrate their operations with supply of farming products or outsource supply from regional countries, where the cost is much cheaper to the detriment of SMEs – this hinders development of local supply network.

Table 2.1: Knowledge Enablers and Dynamic Capabilities for the Agriculture Industry (cont'd)

Advanced Countries	Malaysia
Science and technology knowledge has a **positive and moderate impact** on absorptive capability; but, a **strong and positive impact** on adaptive and innovative capability. In most advanced countries, basic and applied R&D activities in STEM and agriculture related fields are very strong and focussed on key strategic areas that enhance the productivity of both the upstream and downstream industries. Significant resources are also invested to ensure the industry is globally competitive, which include the following: Continuous upgrading of technological infrastructure and R&D capabilities of leading research centres and universities – and ensuring farmers have access to these new discoveries. Second, the support of industries to undertake R&D and commercialisation activities – some of the big players have established leading research centres and work in partnerships with research universities, centres and global players power the next generation seeds, crops and agriculture products and services. Third, the strengthening of industry-university-community partnerships – this is to ensure that R&D undertaken is relevant to all stakeholders and diverse industries are well linked to ensure access to efficient global delivery systems from farm to consumers. Fourth, support the development of 'start-up; firms to get market penetration and reach; while supporting bigger players to enhance their global reach.	Science and technology knowledge has a **strong and positive impact** on absorptive capability. The R&D in the agriculture is behind that in most developed countries. Lack of talented staff in key research priority areas and weak industry-university partnership have led to a majority of the firms in the industry being dependent on foreign technology and know-how to create value for their operations. This suggests that most of the S&T knowledge is to improve the absorptive capacity of a majority of the industry players in Malaysia. Furthermore, most of the SMEs do not have the financial resources to undertake R&D to move up to adapt and modify existing technology. The firms are also risk averse and prefer use technology that has wider market acceptability and viability. Hence, a lot of resources are invested to train workers, engineers and technologists to use existing foreign technology.
Advanced Skills have **a positive and strong impact** on both innovative capability and adaptive capability. In many of advanced countries, significant resources are invested not only to strengthen the STEM research in the agriculture areas; but also develop better farm management methods, software tools, marketing methods, supply chain networks, risk assessment and financial models to support agribusiness. Most of these countries invest in research programs, PhD courses and develop incentive schemes to attract the best talent	Advanced Skills have **a positive and significant impact** on adaptive capabilities only. There has been a significant increase in R&D activities and advanced skills development led by universities such as University Putra Malaysia, other public universities and Government Research Institutes. However, the graduates and talent developed are primarily to adapt existing technology or knowledge that, in most cases, are developed in leading foreign centres of excellence or MNCs. Further, very few local firms undertake

Table 2.1: Knowledge Enablers and Dynamic Capabilities for the Agriculture Industry (cont'd)

Advanced Countries	Malaysia
to the countries to develop the industry in a more 'holistic' way. Strong partnerships between industry and universities also help these countries to foster translational R&D endeavours and bring advanced research in the laboratories and universities to the commercial sector and consumers. The strong linkages between all stakeholders help close the 'knowledge-commercialisation chasm', enabling all economic agents in the industry enhance the adaptive and innovative capability of farmers and enterprises in the agriculture sector.	cutting-edge R&D or innovative endeavours in key areas of specialisation that have significant impact on the industry; the best Malaysian talents tend to be employed by foreign MNCs or migrate to more advanced countries where the opportunities to undertake cutting-edge R&D and career prospects are much better. The lack of a workforce with highly specialised skills, coupled with a serious 'brain-drain' problem, hinders the industry for translating advanced skills development into building innovative capabilities of the agriculture industry.
Knowledge culture has a **positive and strong impact** on all three dynamic capabilities. The level of knowledge competency and ICT literacy among farmers and other key stakeholders in the industry in these developed countries are high. As such, many of them are well informed about developments, market conditions and innovations taking place both in the domestic and global markets. Many of them have access to information and data from government and trade associations; and some undertake their own data analytics to make informed choices and decisions. Through government agencies and trade/industry associations, there is constant sharing of best practices and new innovations across the industry. Further, support is given to universities and research centres to work closely with SMEs via programs such as the Small Business Innovation Research (SBIR) programs to help build not just the technical and scientific capabilities, but also the entrepreneurial acumen. Leading scientists and students are also encouraged to spawn new start-up companies in the agriculture industry that will value-add to other suppliers and other stakeholders in the sector.	Knowledge culture has a negative **impact** on innovative capability. The level of knowledge competency and ICT literacy among farmers and key stakeholders in the industry are relatively low compare to their counterparts in more developed countries. The level of ICT used among the SMEs in the agriculture is relatively low. Many of them rely on government, suppliers or other intermediaries for information, technology and knowledge. There is a culture of dependency among the enterprises, especially among SMEs. This has several negative spill-over effects that hinder innovative capability of the industry. First, many are complacent and desist from undertaking any new innovations or creative ways to enhance the productivity and market opportunities. Second, many of the intermediaries perpetuate the "lock-in" culture, where there are disincentives for firms to adapt or innovate their own line of products or services. Third, many of the SMEs lack resources and are risk-averse in undertaking R&D activities, hence are willing to sell their IP for under-valued cost and this is due to many do not have the skills to value their own innovations. Hence, most of the IP or patents reside with foreign firms or agencies. Fourth, market failures such as monopolistic and oligopolistic behaviour perpetuated by intermediaries tend to lead to wide spread rent-seeking behaviour and hinder the sharing of best practices or ideas across the industry. These lead

Table 2.1: Knowledge Enablers and Dynamic Capabilities for the Agriculture Industry (cont'd)

Advanced Countries	Malaysia
	to a lack of trust in employees and high turn-over rate for talented staff. Many of the talented staff prefers migrating to countries where there is greater recognition for their specialised skills and rewards commensurate their contribution to the firms and industry.
The continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** In most advanced countries, the agriculture industry is seen as a national strategic industry that is critical for ensuring food security for the nation. Significant resources are channelled to ensure all segments of the agriculture value chain is continuously developed in a holistic to enable to industry to remain productive and globally competitive. Resources are channelled to ensure that leading centres of excellence continue to make important scientific and technological breakthroughs to raise the quality and quantity of yield from the agriculture industry. New management, marketing, logistic systems and other key enablers for enhancing the reach and richness of the agriculture industry are continuously developed. As part of the holistic development, diffusion of these innovations to all segments in the agriculture innovation systems (AIS) is put in place. These are to ensure that AIS builds strong absorptive capability of new technology, scientific discoveries and management systems among all segment of the agriculture community. The strong adsorptive capability with good enablers for firms to continuously modify and improve products and services will raise the adaptive and innovative capability of the industry. As part of the holistic development of AIS, careful planning and implementation plans are put in place to ensure that the AIS in these countries are closely aligned with ecosystems in other industries, in particular with the manufacturing, ICT services, telecommunication and logistic industries. The AIS in these countries also give specific attention	The continuum from absorptive capability to adaptive capability to innovative capability **is present.** While there has been a significant increase in investment to increase the amount of talent in the agriculture and agribusiness areas, the graduates that enter these professions are not the best talent in the field. The best students tend to pursue courses in other STEM or business related fields. Furthermore, the lack of adequate number of students pursuing research programs and firms undertaking cutting edge R&D that is relevant in the country is also one of the reasons for the industry to build adequate innovative capability. Most of graduates or talent developed are good for absorbing and adapting advanced technology from more advanced countries and MNCs. Due to lack of R&D endeavours among local firms, many of them tend to modify foreign technology to meet both local and regional demand. Many of the local firms prefer to be part of the foreign firms supply network, providing services and support to foreign firms to produce more innovative and creative products and services for the global market. Ultimately the IP and patents are owned by foreign firms. The local cluster network is not strong – many parts of the cluster is not functioning well, especially access to cutting-edge scientific endeavours from universities and GRIs; weak linkages between agriculture and the manufacturing industry; and the industry is plagued by fragmented and unsophisticated logistic supply network. To bypass these challenges, many of the firms prefer working closely with large foreign players who are able to

Table 2.1: Knowledge Enablers and Dynamic Capabilities for the Agriculture Industry (cont'd)

Advanced Countries	Malaysia
to more effective management of the environment and natural habitat so as to ensure that agricultural practices ensure more effective management of the resources for the future generations. Many of these countries' adherence to global environmental standards and best practices which are key in ensuring long-term sustainability and competitiveness of the industry.	provide the best technology and market access. This at times has an adverse impact on nurturing the local agriculture supply network.

The impact of dynamic capabilities on economic outcomes for the agriculture industries for both advanced countries and Malaysia are summarised in **Table 2.2.** In advanced countries, adaptive capability was found to have a positive and strong impact on process improvements; and, positive and moderate impact on product market outcomes. On the other hand, innovative capability was found to have a positive and strong impact on process improvement and a very strong impact on product market outcomes. This suggests that in the agriculture industry, both the upstream and downstream industries are very strong in producing process improvement and generating new market outcomes.

The empirical analysis for the Malaysian agriculture industry shows that absorptive and adaptive capabilities were found to have a strong and positive impact on process improvement only. Innovative capability was found not to have any significant impact on process improvement or new product outcomes. The result suggests that the agriculture industry undertake the following: employ cheap foreign labour; adopt technology and innovations; and improve systems and processes to remain cost competitive. Development of downstream industries that has wider global reach and richness remains in their early stage of development

Table 2.2: Dynamic Capabilities and Economic Outcomes for the Agriculture Industry

Advanced Countries	Malaysia
Adaptive capability has a **positive and strong impact** on process improvement and a **positive and moderate impact** on product market development. There are a wide range of firms that operate in different levels of the innovation value chain. A majority of the SMEs in this industry are very strong in adapting new technology and innovations to improve existing products and services. They also play a key role in supplying products and services for the larger MNCs in the industry. Some of enterprises are new start-up firms that emerged from universities and research institutes to create new applications and innovations that value-add products and services of other players in the	Absorptive and Adaptive capabilities have **positive and strong impact** on process improvement only. The upstream industries (small holder, SMEs and large players) are labour intensive not technological savvy. Many of them use foreign technology and innovations, where possible to improve their processes and value chain. However, they still rely on cheap foreign labour to work in the plantations. The downstream industries are primarily dominated by large Malaysian and foreign firms. A number of foreign SMEs are very competitive in the downstream industries.

Table 2.2: Dynamic Capabilities and Economic Outcomes for the Agriculture Industry (cont'd)

Advanced Countries	Malaysia
industry. There are also another set of players (MNCs) that emerge from these countries that operate in the upstream and downstream industries in their own countries, but also in other countries. The MNCs control the supply of the products and services and also the retail and supply networks. These give them greater opportunities to pursue both economies of scale and scope at the global level.	The local firms build their capability by leveraging on knowledge technology developed in more advanced countries. Much of the focus is to enhance process improvements. There are firms in the industry that able to produce niche products primarily adapting existing technology for the local and regional markets. An area that has the potential to be developed is the halal industry. At present the agriculture ecosystem has not fully realised the potential of the halal industry in the region and globally due to weakness in supply networks.
Innovative capability has a **positive and strong impact** on process improvement and a **positive and very strong** impact on product market outcomes. There is a significant investment in R&D and skilled workforce by government institutions, universities for the upstream and downstream industries. This enables firms to produce more efficiently and enhance their productivity; at the same time introduce new innovations, products and services. Many of the firms, especially the large MNCs, have global reach and richness in the products and services. The global firms are also competing to developing very strong brand identity.	Innovative capability **has no significant impact** on process improvement and product market development. Most local firms adopt new technology and innovations from more advanced countries to improve cost-efficiency, service quality and meet domestic market demand. The quality and quantum of R&D and innovations undertaken by local players are relatively low compared to their foreign counterparts from the respective sample countries. Hence, the innovations undertaken by local players do not have a significant impact on product market development.
Process improvement has a positive and **moderate impact** on product market outcomes. The agriculture clusters are well developed and form strong partnerships with other clusters that enable firms to translate the process improvements into new product development. The new processes developed are not only contributing to new product development in the domestic economy; they are also adapted by other countries, especially agriculture industry from the developing world. Some of the process improvements are patented and licensed to firms in both the domestic economy and to firms in other countries.	Process improvement **does not impact** product market outcomes. A majority of the process improvements undertaken by firms in the industry are based on foreign technology and intellectual property. Hence, the potential of creating new products and services from the borrowed IPs are limited for the local firms.

2.8 Summary: Key Trends, Challenges, Way Forward and Best Practices

2.8.1 Industry Trends

Overall, the agriculture industry shows weaknesses in knowledge resource foundations. Firms in the agriculture industry experienced a general decline in their level of knowledge content over the period of 2007 to 2014, though they managed to demonstrate improvement in leadership, infostructure and knowledge sharing. Despite these positive developments, agriculture still lags behind other industries. The gap between agriculture and national aggregate level across all knowledge enablers and knowledge actions continues to be large. Other than human capabilities and leadership, local large and small firms show similar patterns in knowledge content.

As a result of having weak knowledge foundations, the industry is unable to generate strong dynamic capabilities. The area of weakness is in adaptive and innovative capabilities. Firms in the agriculture industry are not well engaged with institutional agencies, and have insufficient support especially in human capability development and process improvement. Human capability is a pertinent issue, with the industry having more computer science and engineering graduates than agriculture science and biotechnology graduates. The weakness in human capability poses problems to the industry's ability to respond to opportunities. This weakness is compounded by low levels of investment in innovative capability building processes and activities. Unsurprisingly the industry has a dominant presence of Defender and Reactor firms who exhibit a weak appetite for introducing genuine new products to the market. The approach of the industry is to adopt technologies and techniques invented elsewhere rather than innovate by themselves.

Notwithstanding the current position of weakness in building its knowledge foundations, the agriculture industry is of critical importance to national food security and also continues to be a significant contributor to the Malaysian GDP. As Malaysia shifted from an agrarian to a manufacturing and services based economy, the fortunes of the agriculture industry slipped in lockstep. The agriculture industry's ability to independently feed the population has eroded, and the need for food imports has continued to grow in earnest. Given that food security is key to national wellbeing, it is imperative to re-focus on building the agriculture industry's dynamic capabilities and competitiveness.

To transform the agriculture industry into a knowledge-driven industry, the Malaysian government have introduced several incentives and support schemes in all the five year economic plans, including the 11th Malaysia Plan. To enhance downstream industry, a number of projects as part of the Entry Point Project (EPP)-Economic Transformation Programme (ETP) were introduced. Among them include the commercialisation of epoxidised natural rubber (Ekoprena) and deproteinised natural rubber (Pureprena), through the introduction of new technology for new generation of latex grade specialty rubber. This is to create raw materials for the production of high end rubber products, such as eco-friendly green tyres.

2.8.2 Challenges

The agriculture industry is an important contributor to the Malaysian economy. However, it remain low in knowledge content due to a number of challenges outlined below.

Institutions:

- A number of strong institutions cater for the agriculture industry, such as MARDI, RRI, FAMA and others. However, a lack of effective coordination and cooperation across the multiple institutions, such as GRIs, educational institutions, government agencies and trade/business associations hinders systematic and holistic planning and development of the agriculture industry.

- Insularity of firms renders cooperation and collaboration rare between industry stakeholders.

- Lack of development in the local supply network – potential industry-wide synergies are unachieved due to poor linkages between upstream and downstream industries.

- SMEs lack access to market-leading R&D discoveries and capabilities; hence spill-over benefits and knowledge-transfer between research institutions and agriculture communities, especially the SMEs, is very minimal.

Basic Skills Development:

- Labour-intensive due to low mechanisation in specific operation processes.

- Over-reliance on foreign workers, as industry fails to attract local talent due to unattractive career prospects.

- Skilled workers are scarce, due to failure to capture and retain talent, as well as working conditions and job requirements that do not encourage talent development.

- SMEs have a major challenge recruiting experienced and competent staff.

S&T Knowledge:

- Shortage of talented staff in key priority areas caused by brain-drain of capable labour force to other markets.

- Skills of graduate do not meet the needs of creative work in the industry – most of S&T graduates are good users of foreign S&T but are not creators of new innovative systems.

- SMEs have major challenges recruiting high calibre workers – most qualified individuals have high wage expectations, and opt to work overseas or with MNCs.

- SMEs lack financial resources to undertake R&D to adapt and modify existing technology.

- SMEs are risk averse and prioritise current business continuity over incorporating process innovations.

Advanced Skills Development:

- Ageing workforce due to dwindling interest and lack of participation from younger generations.

- Lack of specialised skills to meet the needs of creative workers in the industry – most graduates and talent developed are focussed on adapting existing technology and knowledge not creation of new innovations.

- Only large firms and MNCs have staff with advanced knowledge and skills to creatively pursue innovation, reconfigure knowledge and apply knowledge in a complex way.

- SMEs have major challenges recruiting high-calibre workers – businesses have evolved to be dependent on a low-sophistication workforce, and do not accommodate high-worth human capital well; emigration of local talent further thins the pool of capable candidates.

- Lack of trainers and credible training courses.

Market Intelligence:

- Weak linkages among stakeholders inhibits dissemination of knowledge.

- Distrust and insularity among firms cause the industry to rarely pursue collaborative efforts.

- Monopolistic behaviour due to incumbency of intermediaries in specific markets perpetuates 'lock-in' of smaller players.

- Rent-seekers shift focus of industry toward cost optimisation rather than investment-centric decision making.

- Low use of ICT and new technologies limit the access valuable information among industry executives.

2.8.3 Way Forward

The agriculture industry is a key industry for ensuring food security, employment, source of supply for higher value added industries, such as manufacturing and a source of income for the nation. Intense competition from regional economies with a larger labour pool and from more developed countries with more sophisticated technology under a more open economic environment under the Trans-Pacific Partnership Agreement (TPPA) will require local players in the agriculture industry to quickly move up the knowledge and innovation value chain to ensure their competitive position on the global agricultural value chain. The key recommendations for enhancing the knowledge intensity and innovative capacity of the industry are highlighted below, based on the empirical evidence of the Malaysian agriculture knowledge ecosystem and roundtable discussions with key industry players, government agencies and trade associations.

Recommendation 2.1: Holistic Talent Development Strategy

- Facilitate, encourage and promote:
  - Skills training program through introduction of agriculture courses as a major in high school, technical colleges and polytechnics, working closely with major industry conglomerates.
  - Young agropreneur training programs to rebalance workforce age demographics.
  - Cost-effective continuous vocational training programs (leading to certification) need to be made available via colleges and polytechnics.

- Prioritise the development of human capability and introduction of skills-oriented KPIs to enforce knowledge cultures toward achieving quality and efficiency.

- Foster strong university-industry collaboration in curriculum design, course development, internships and work placements that will benefit the agriculture industry.

- Develop large scale university-industry research programs and doctoral courses in the above mentioned areas and applications.

Recommendation 2.2: Intensify Basic and Translational R&D

- Establish priority areas of R&D (connecting to global demand and enhance productivity of local industries):
  - Greater alignment of the *National Bio-technology Plan and National Bio-Economy Plan* with the needs of the agriculture industry.
  - Encourage greater interaction between firms in this industry with the Life-Sciences Cluster, in particular the Biotechnology cluster to increase capital, R&D activities and patent applications on local crops, fishery and farm products.
  - Establish transnational research centres that work with leading global centres of excellence to develop indigenous technology and innovations –training of global innovators, leaders and thinkers in the field.
  - Government Research Institutions' involvement in R&D&C and its direct involvement in the dissemination of knowledge and training should be intensified – this can be done by channelling funding such as the *Small Business Innovation Research* (SBIR) funding to the GRIs with clear KPIs for technology and knowledge transfer to Malaysian SMEs in the agriculture industry.

Recommendation 2.3: Develop a Modern and 21st Century Logistics Network

- Establish a modern integrated logistics supply chain network by:
  - Strengthening the governance systems to prevent rent-seeking behaviour.
  - Streamlining and simplifying regulations.

- Using the digital architecture to instil greater transparency and speed cargo clearance.
- Increase greater connectivity to rural farms and communities and providing cost-efficient transportation services.
- Training talent to develop and manage a modern logistic supply chain that connects the Malaysian agriculture industry to the global supply network.

Recommendation 2.4: Establish More Effective Institutional Coordination Among Key Stakeholders

- Establish a high-level panel consisting of key stakeholders to develop a strategic master plan for the agriculture industry with clear KPIs, resources and outcomes to raise the innovative capacity and competitiveness in key priority areas.
- A centralised helpdesk to work closely with offices at the district level, hence respond efficiently to doubts and issues raised by farmers at the ground.
- Incentivise government bodies to gazette fertile land for agriculture development.
- Ministries and government agencies should have more "outreach" exercises to engage with the industry associations to gather intelligence on the following:
  - Information and expertise available in the country.
  - Availability of testing facilities.
  - Training needs of industry.
  - Workshops and seminars to expose farmers and agriculture community to new advancements innovations in the field.
  - Programs offered by FAMA, MARDI and other GRIs are commendable and should be intensified and made more accessible to SMEs and rural farmers.

Recommendation 2.5: Collaborative Platforms for Specialised Knowledge and Business Development

- Establish a 'One-Stop Centre' for industry to access the following:
  - Funding opportunities for business development (such as microfinance, technology funding and other funding sources).
  - Rules and regulations on trading in the ASEAN region and other major trading partners.
  - Expertise in local institutions that farmers can access.
  - Laboratories and specialised equipment that farmers can use to enhance their productivity.
  - Use of modern technology to gain access to supply the network and promote their products and services to a wider segment of the market in Malaysia and the region – improving market intelligence.
  - Acquire the knowledge to package and brand products and services to meet national, regional and global markets.
  - Ability to translate local knowledge on farming and product development into explicit knowledge and IP that has commercial value.
  - Information on certification process to meet key markets in advanced countries and Muslim consumers.

Recommendation 2.6: Standards and Certification as Drivers of Market Growth

- Create awareness among SMEs to comply to MyGAP initiatives.
- Certification, appropriate protocols and patenting process should be simplified and cost-effective for SMEs and startups.
- Incentivise firms to comply with these standards and certification.

2.8.4 Best Practices

Over the next few years, opening of the regional markets within ASEAN and the Asia-Pacific region to foreign firms is envisaged to increase competitive pressure for local firms in the agriculture industry. To increase the agricultural competitiveness, local firms can learn from the best practices that have in many ways significantly improved agriculture production and management in more developed economies.

Best Practice 2.1: Holistic Talent Development Strategy

UK-Young Entrance Support Schemes.

- *Young Entrants Support Schemes* (YESS) encourages the younger generation to join the talented workforce in agriculture. YESS in UK has introduced a number of programs. Among them are:
  - Grant for young entrants.
  - Mentor-mentee program, whereby established farmers act as coaches/mentors to provide guidance to new and young workers in the industry.
- Clear articulation of pathway in higher education from certificate to doctoral program in institutions of higher learning.
- Curriculum for the program is designed collectively with key industry players, trade associations and universities (institutions) aligned national strategic priority industries – this is to ensure the program is relevant and meet the needs of the industry.
- Job training, internship, apprenticeship and mentorship are key components in the education & training program so that graduates are job-ready.
- Remuneration is competitive to ensure:
  - Continuous improvement of the teaching and learning environment.
  - Access to high quality professional development programs for educators.
- Publicity campaigns are jointly done with industry to highlight the benefits of agriculture education in the local media, digital platforms and meetings. This includes showcasing achievements of students to the community. By doing so, the publicity campaigns increase interests among the young talent, establishing themselves as a choice industry for their careers.

Best Practice 2.2: Intensifying Basic and Translational R&D

US Department of Agriculture - Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR) program

- These programs are led by the federal agencies that use partnership intermediaries to facilitate transfer of technology between the Agricultural Technology Innovation Partnership (ATIP) and Small Business Innovation Research (SBIR) program.
- The strategic partnerships are between SMEs, universities and government agencies to support innovation to stimulate technological innovations in the agriculture sector.
- The STTR program is promoted to foster technology transfer via collaboration between small businesses and research institutions; and increase commercialisation of government funded R&D key national strategic priority areas, such as agriculture.

Best Practice 2.3: Developing a Modern and 21st Century Logistics Network

Flora Holland Logistic and Supply Network

- Close to 20 million plants and flowers (90% of the nation's output) are traded via this supply chain.
- This supply chain is supported by 5000 members, 9000 suppliers, 3500 customers and 4500 employees, and creates 250,000 full time jobs globally.
- Supported by a sophisticated airport (Schiphol), logistics space equivalent to 200 soccer field for transport vehicles, office building, and processing plants.
- Advanced technology is used to manage the complex supply network (covering grower to traders) that enables plants and flowers to be transported to and from the airport to any destination across the globe.
- Advanced co-operative trading platform consisting of specialised growers, specialist traders and mega-chain stores across the globe to bid on millions of plants and flowers sold every day.
- Strong cooperation among all stakeholders and an efficient logistics supply network enhances the global competitiveness of Holland's horticulture industry, but also transforms the nation into a global hub for international trade.

Best Practice 2.4: More Effective Institutional Coordination Among Key Stakeholder

GROWING FORWARD 2 (2013-2018: A 5 year Federal-Provincial-Territorial Initiative), Canada

- Strong cooperation among all stakeholders position the nation's agriculture and agrifood sector for growth and prosperity via the following programs:
  - *AgriInnovation Program* – investing in the development of science & technology, development & commercialisation of new products and services in key priority areas.
  - *Agri Marketing Program* – helping industry to adopt food safety and traceability systems and expanding new markets.
  - *AgriCompetitiveness Program* – improving profitability in domestic and global markets
  - *Cost-Share Programs* – help provide flexibility to provinces to design and deliver programs that meet the needs of farming communities in the respective provinces; and also help farmers manage risk due to severe market volatility and natural disasters.
  - *Business Risk Management Program* – innovative investment, stabilisation, insurance, natural disaster recovery program and other new private & producer funded agriculture risk management tools.

Best Practice 2.5: Collaborative Platforms for Specialised Knowledge and Business Development

WEGENINGEN UNIVERSITY, Holland – World's No 1 University for Agriculture Education

- This institution hosts a number of research institutes that undertake leading research in the areas of: high quality and sustainable green living and crop management; live stock research; healthy food, fresh food chains and bio-based products; marine ecology; socioeconomic agriculture models and data analytics; food safety and detection; and greenhouse horticulture.
- The institution also provides industry access to a host of researchers, laboratory and business development facilities, including developing software and apps for the industry.
- Training provided by the institution covers a wide range of courses for undergraduate, postgraduate and doctoral students in the agriculture and agribusiness fields of study. The university also offers online courses, short courses and professional training for industry and practitioners. The university also works very closely with major global food producers, such as Heinz and Danone.

Best Practice 2.6: Standards and Certification as Drivers of Market Growth

FOOD STANDARDS AUSTRALIA NEW ZEALAND

- A leading bi-national independent statutory agency that develops and ensures that industries meet global best practices pertaining to food, food additives, food safety, labelling, genetically modified (GM) foods, food traceability.
- Ensure harmonisation of national best practices to global best practice - a key source of global competitiveness and market penetration into OECD countries.
- Industry support to comply to standards and regulations and user guide – detailed website containing standards, policies and regulations are available.
- Comprehensive online information for consumers is provided on additives, chemicals in food, food allergies and intolerances, food safety and recalls; food technologies and novel foods, GM foods, imported foods, labelling, nutrition and fortification and other food related information.
- The agency is supported by broad range of in-house expertise, with scientific skills to undertake risk analysis and appropriateness of regulatory measures.
- Scientific experts also contribute to scientific publications in the field which are then made accessible to the global agriculture industry.

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CHAPTER 3

KNOWLEDGE CONTENT OF THE FOOD PROCESSING INDUSTRY

CHAPTER 3
Knowledge Content of the Food Processing Industry

3.0 Introduction

The food processing industry is an important component of the Malaysian economy. It is strongly linked with the agriculture industry for raw materials, which are transformed through processing into value-added intermediate and final products. The major agriculture feed stocks into the food processing industry are fish and fish products, livestock and livestock products, fruit, vegetables and cocoa (MIDA, 2015). Malaysia is a central player in the global supply chain for several crops; for example:

- Malaysia is currently the **largest cocoa processor in Asia** and fifth largest cocoa producer in the world.
- Malaysia is the **world's sixth largest exporter of pepper** and pepper-related products (specialty peppers, processed pepper and pepper sauces) (GAIN, 2014; MIDA, 2015).
- Malaysia is the **third largest producer of poultry meat** in the Asia Pacific region. Malaysia is self-sufficient in poultry, pork and eggs, but imports about 80% of its beef (MIDA, 2015).

Whilst certain Malaysian agriculture produce hold sway in international markets, it is important to note that local yields alone are insufficient to support the nation's food processing industry. For example, even though Malaysia is the world's fifth largest cocoa producer; its local cocoa bean production is unable to cope with the huge demand from the local grinding and processing industries. In fact, the country imports 95% of the cocoa beans consumed by the food processing industry (MIDA, 2015).

Such reliance is indicated by the self-sufficiency level (SSL) of key agro-based food industries (**Table 3.1**).

Table 3.1. Malaysian Self-sufficiency Index for Agro-based Products

Agro-based products	2005	2010	2013
	Self-Sufficiency level (SSL) %		
Rice	80.58	71.39	72.25
Fruits	74.06	65.75	68.45
Cattle	21.15	28.65	29.77
Vegetables	46.23	41.17	48.61
Milk	4.59	4.88	5.23
	Self-sufficiency Level of Food Commodities, 2010 – 2020 (%)		
	2010	2015	2020[1]
Crops			
Rice	63.1	71.4	106.5
Fruits[1]	103.3	101.6	106.5
Vegetables[2]	89.8	91.8	95.1
Livestock			
Beef	30.1	27.2	50
Mutton	12.2	17.3	24.6
Poultry	105.6	104.6	103.7
Pork	94.7	88.7	83.1
Eggs	114.6	122.1	130
Milk	8.5	13	13.6
Fish[3]	93.9	92.6	95.8

Note: [1]excludes temperate fruits; [2]excludes temperate vegetables; [3]includes seaweed;
SSL= Production / (Production+ImportStock-Export) x 100
Source: ETP Annual Report (2014), Economic Planning Unit (2015).

As of 2015, Malaysia's major food imports are sugar and sugar confectionery (RM3.4 billion), dairy products (RM3.2 billion), cereal and cereal preparations (RM1.5 billion), vegetable and fruits (RM1.2 billion) and cocoa preparations (RM1.0 billion) (MIDA, 2015).

Malaysia also imports processed food, which ranks among the ten most imported items in Malaysia. As shown in **Table 3.2**, import of processed food increased to close to RM17.78 billion in 2015 from RM16.98 billion in 2014. In comparison, the export of processed food amounted to RM18.01 billion in 2015. Overall, the statistics demonstrate that Malaysia was a net importer of food in 2014 and has become a net exporter in 2015.

Table 3.2: Imports and Exports of Food (Top Five Destinations) 2014/2015

Food	Country	2015 (Provisional Data)		2014	
		RM million	Share %	RM million	Share %
Imports	**Total**	**17,777.6**	**2.6**	**16,979.6**	**2.5**
	Thailand	2,036.2	0.3	2,127.4	0.3
	New Zealand	1,966.4	0.3	1,981.3	0.3
	China	1,733.0	0.3	1,339.2	0.2
	Indonesia	1,730.9	0.3	1,453.2	0.2
	Brazil	1,531.1	0.2	1,872.3	0.3
Export	**Total**	**18,010.6**	**2.3**	**16,559.8**	**2.2**
	Singapore	2,342.5	0.3	2,151.8	0.3
	China	1,510.1	0.2	1,147.5	0.1
	Indonesia	1,345.8	0.2	1,339.2	0.2
	Australia	1,148.2	0.1	1,189.5	0.2
	Thailand	1,026.6	0.1	894.6	0.1

Source: Ministry of International Trade and Industry [MITI] (2016)

The structural composition of the food processing industry of Malaysia shows that 80% of the food processing industry is composed of SMEs. These smaller enterprises are labour-intensive operations relying heavily on low-end, more accessible technologies. Several MNCs (such as Nestle, Unilever, and Campbell Soup) have located their regional production in Malaysia, and use it as a base to serve the Malaysian market as well as for exports to the region. In contrast to SMEs, these large firms characteristically have in-house R&D facilities and plants equipped with state-of-the-art modern technologies. These ultimately translate to a significantly stronger brand proposition and market advantage which SMEs do not demonstrate at this point.

3.1 Key Developments and Initiatives

Being a Muslim majority country, the Halal food industry is the largest and most important segment of Malaysia's food processing industry. It is estimated that the number of export-ready Halal companies will reach approximately 1,600 by 2020, up from the 900 companies present as of end-2014 (MITI, 2014). Export contribution from local Halal companies as a percentage of overall Halal exports is forecasted to increase from 21.0% in 2014, to 50.0% by the year 2020. Additionally, the growth and development of Halal companies is expected to provide 330,000 employment opportunities by the year 2020.

A number of initiatives are driving the growth of the Halal food industry:

Halal Business Transformation (HBT) Programme. In June 2011, the Malaysian Government initiated the programme to enhance the operating capabilities of local companies and scale them up to become globally competitive players in the Halal food industry. As of December 2014, a total of 1,300 Halal-certified companies had received assistance under the programme.

Development of Halal Parks. As of 2016, Malaysia had set up 21 Halal Parks (Halal Industry Development Corporation, 2016). Of these 21 parks, 13 have been awarded the HALMAS status, under which the business operators in the park can claim various incentives according to the Halal industry guidelines.

SME Mentoring Programme. An initiative by SME Corp. Malaysia, with Nestlé (Malaysia) Berhad and Halal Industry Development Corporation (HDC) to mentor SMEs in the food and beverage industry on production, sales, marketing and in Halal-related matters since 2009. A total of 243 SMEs have to date benefited from this mentoring programme.

The **Market Development Grant (MDG)** from **MATRADE** assists SMEs to undertake promotional activity in export markets. Food manufacturers who meet the criteria can apply for this grant (MATRADE, n.d).

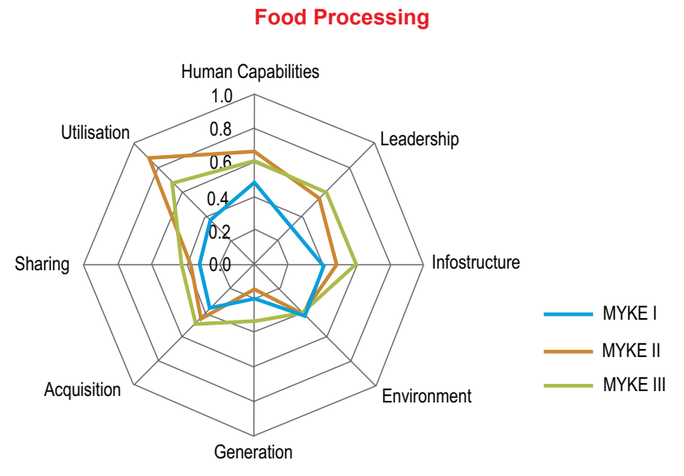
The potential for Malaysian food processors to grow remains immense given the global demand dynamics, especially in Halal foods. The estimated value of the Halal food industry globally is between US$600 billion and US$2.1 trillion (Austrade, 2014). The halal food industry is estimated to grow by 5.8 per cent by 2020 (Times, 2015). Halal is recognised as a benchmark for quality, hygiene and safety for Muslims. However, this this perception is also gradually spreading to Non-Muslim segments across the food chain, especially in light of food chain contamination scares (Food Export Association of the Midwest USA, 2014). The acceptance of Malaysian Halal food products has been helped by the strong awareness of Malaysia's Halal standards and mainstream acceptance of Malaysia's Halal logo. This has facilitated strong stable global demand for Malaysia's Halal products, and the demand is expected to keep growing.

3.2 Knowledge Content

Malaysia's food processing industry has been making good progress in terms of its knowledge content. In 2003, the industry was performing below the Malaysian industry average in almost all knowledge areas. By 2014, this position has changed dramatically with almost all knowledge elements in food processing industry scoring above, or at least on par, with the Malaysian industry average.

Among all knowledge elements, infostructure demonstrated the greatest improvement (see **Figure 3.1**). Although there was significant improvement in human capital and knowledge utilisation from 2003 to 2007, the score dropped in 2014 indicating an inability to sustain the headways made in the earlier period.

Figure 3.1: Overview of Knowledge Enablers and Knowledge Actions for MYKE I, II and III.



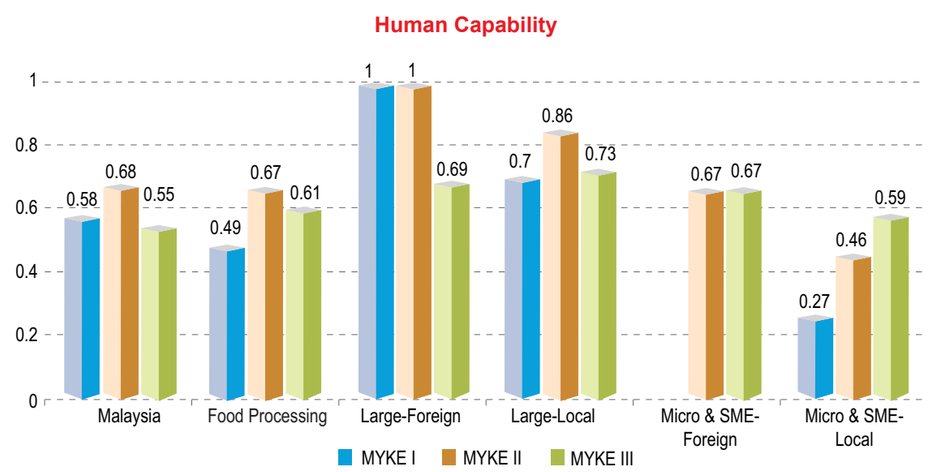
3.3 Knowledge Enablers

3.3.1 Human Capabilities

Human capability in the food processing industry increased in 2007 but declined slightly by 2014 (see **Figure 3.2**). This is in line with the national decline in the area of human capability. The food processing industry performed lower than the national aggregate over the period 2003 to 2007, but by 2014 had risen above the national aggregate. Large local firms show a similar trend, whereby there is an increase in 2007 followed by decline in 2014. The strongest improvement has been in the performance of local micro and SME firms, which exhibited year-on-year improvement and are catching up with large firms in terms of human capability. These improvements have been driven by the higher willingness of SMEs players in the food processing industry to invest in employee training.

The food processing industry is becoming an increasingly attractive employment destination among graduates, particularly degree-holders. How well-matched these graduates are to the needs of the industry remains debatable given the low number of individuals with qualifications specifically related to food processing, such as food science and food technology. As highlighted by industry players in our interviews conducted, firms in the industry have problems finding highly qualified employees in food science.

Figure 3.2: Human Capability of the Food Processing Industry



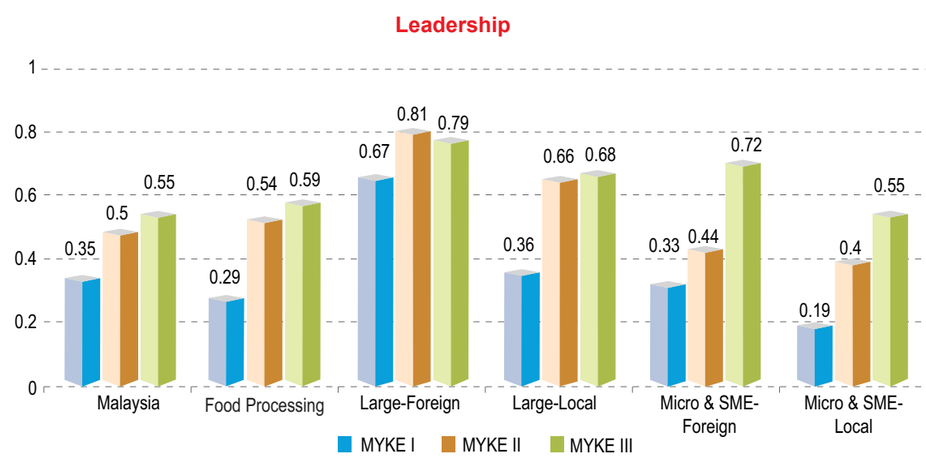
Note: Number of large foreign and SMEs from the sample were low. Hence, meaningful comparison between foreign and local firms may not be feasible.

3.3.2. Knowledge Systems and Leadership

Malaysia's food processing industry progressed positively in terms of knowledge-leadership. It performed above national aggregate in 2007 and 2014, although only marginally. In 2014, better performance was observed among foreign players across the board. Compared to their local counterparts, these organisations have more formalised processes that are better structured for developing and documenting knowledge and information. Increase in food volume necessitates better precision in line-production systems, from the amount of ingredients to the timing and temperature of each stage, and so on. This critical information and knowledge needs to be documented within the manufacturing process instead of relying on the iterative experience of workers, as commonly practiced in small sized operation.

Local micro and SMEs scores have risen from 0.19 in 2003 to 0.4 in 2007 and 0.55 in 2014 (see **Figure 3.3**). This indicates that micro and SMEs are increasingly formalising their knowledge processes and systems. With tighter requirements for food safety and quality both from government and consumers, it has become important for firms to attain certification such as HACCP and/or other halal certification. Furthermore, firms that aim to engage in the export business need to have ISO certification to assure quality. This has led micro firms and SMEs to have systematic documentation and proper processes in place.

Figure 3.3: Knowledge Leadership in the Food Processing Industry



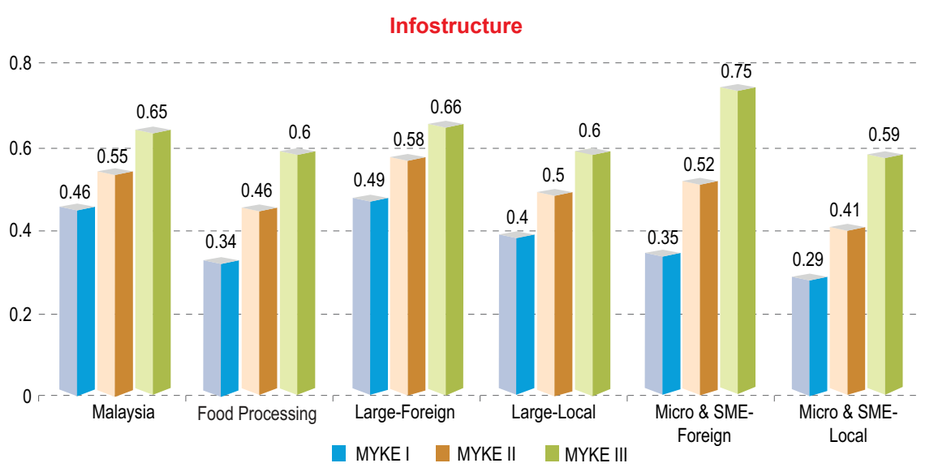
Note: Number of foreign (large and SMEs) agriculture firms in the sample are low, and hence caution must be taken in interpreting figures comparisons of these groups.

3.3.3 Technology and Infostructure

In terms of infostructure score, the food processing industry improved steadily from 2003 to 2014 (see **Figure 3.4**). In 2014, the score is almost on par with the Malaysian industry average. These figures demonstrate that food processing companies, even local micro and SMEs firms, are increasingly investing in computer technology and utilising e-commerce as an important means of trade.

Many small businesses use technology to create direct contact with customers and also improve their visibility through company webpages, as well as to source for suppliers on the internet. Additionally, a number of firms are starting to utilise online purchase systems, thereby developing altogether new e-commerce technological capabilities that were unprecedented within the individual organisations.

Figure 3.4: Technology and Infostructure of the Food Processing Industry

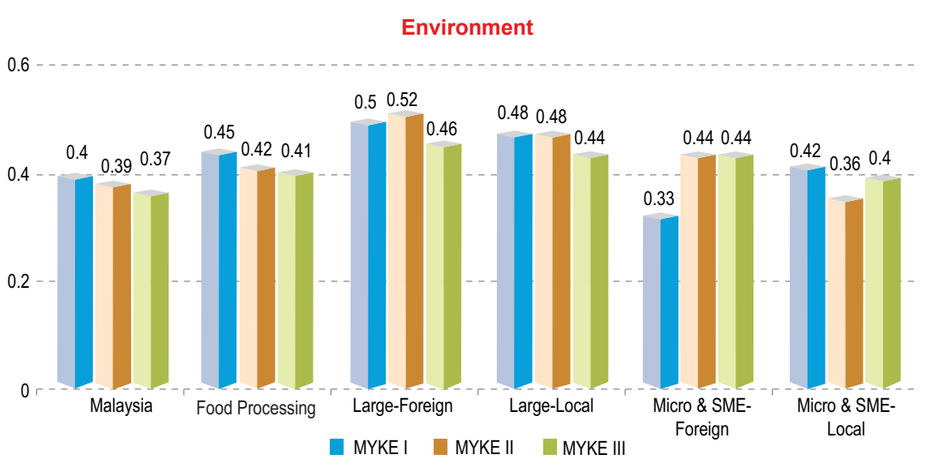


3.3.4 Knowledge Environment

In contrast to most other knowledge enablers that demonstrated an improvement over the years, the food processing industry's knowledge environment score dropped marginally from 0.45 in 2003 to 0.41 in 2014. However, this remains above the Malaysia industry average (see **Figure 3.5**).

Regardless of size or origin, food processing firms are actively engaged with industry associations, and also seek information and support from various government agencies. Awareness of changes in government plans and policies and assistance grants are vital pieces of information for business operations.

Figure 3.5: General Environment Awareness of the Food Processing Industry



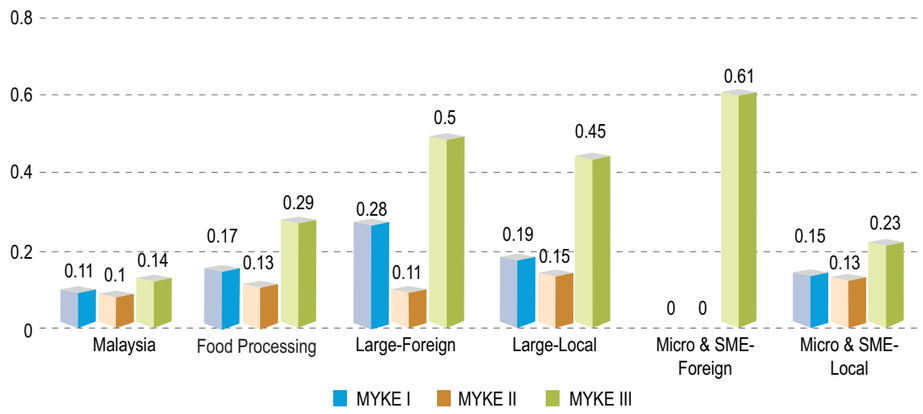
3.4 Knowledge Actions

3.4.1 Knowledge Generation

The score for knowledge generation in the food processing industry remained above the Malaysia industry average over the periods 2003 to 2014 (see Figure 3.6). Nonetheless, the level of knowledge generation is low. The score of knowledge generation for the industry was 0.17 in 2003, dropping very slightly to 0.13 in 2007. The score picked up again reaching 0.29 in 2014, almost double the score of the national aggregate.

By 2014, both large and small foreign firms become more active in knowledge generation activities including patent and copyright filing and R&D as compared to local firms. However, the rising trend of knowledge generation in local firms is quite promising. Over time more local firms are conducting some form of R&D activity in their business. However, R&D activities in local food processing firms are largely limited to alterations of flavour, ingredient mixes, and simple adjustments to technology and processes to cater for Malaysian tastes and preferences, which differs from the specialist knowledge-intensive R&D generated by foreign firms.

Figure 3.6: Knowledge Generation Activity in the Food Processing Industry

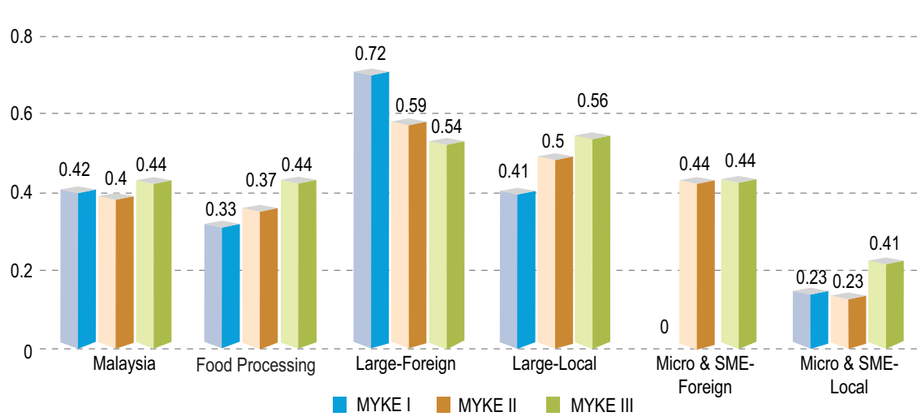


3.4.2 Knowledge Sharing

Knowledge sharing in food processing industry increased steadily from 0.33 in 2003 to 0.44 in 2014 (see **Figure 3.7**). The score in 2014 was the same as Malaysia industry average. Overall, large firms (both foreign and local) tend to engage more actively with knowledge sharing activities compared to smaller firms. For example, large firms tend to utilise dedicated project management teams more commonly in their business operations. Knowledge sharing within firms is facilitated through these formal structural forms

Local micro and SMEs are also improving in knowledge sharing moving from a score of 0.23 in 2007 to 0.41 in 2014. This is indicative of a higher level of sharing knowledge internally and externally with other firms.

Figure 3.7: Knowledge Sharing Activity of the Food Processing Industry

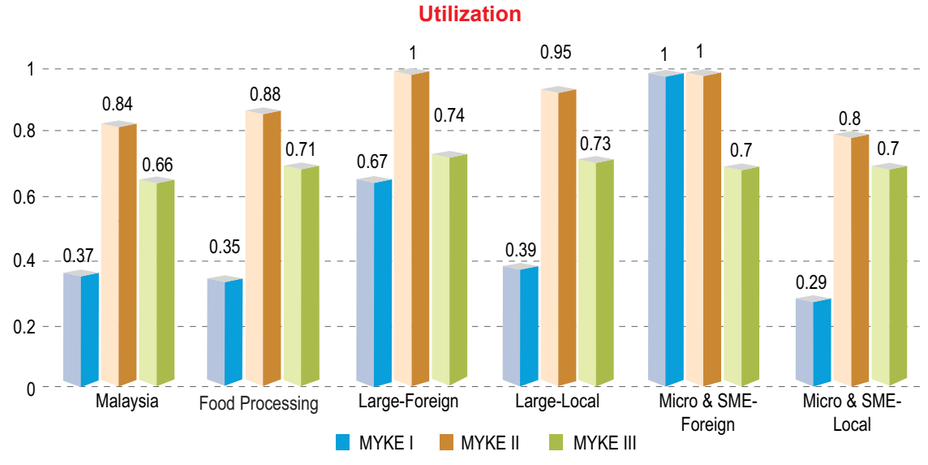


3.4.3 Knowledge Utilisation

Knowledge utilisation in food processing rose rapidly from 0.35 in 2003 to 0.88 in 2007, with a slight drop to 0.71 in 2014 (see **Figure 3.8**). In 2014, this score is higher than the Malaysian industry average of 0.66.

Similar trends are observed among the different firm categories, showing that food processing companies have become adept at applying experiential and external knowledge. In most cases the firms have adapted external knowledge to their specific needs rather than generate new knowledge through R&D investment.

Figure 3.8: Knowledge Utilisation Activity of the Food Processing Industry



3.5 Dynamic Capabilities Profile for Food Processing Industry

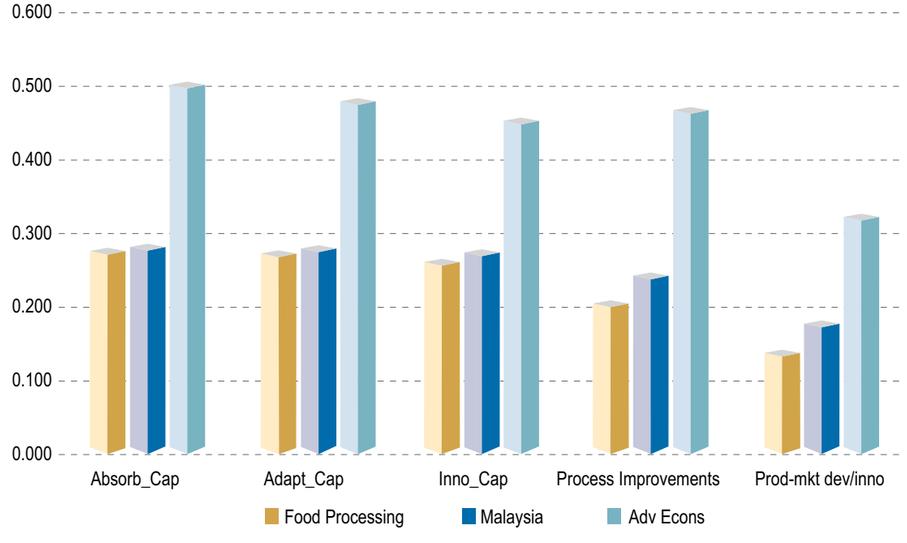
Developing strong knowledge foundations is an important part of building dynamic capabilities. The food processing industry shows promising growth potential, evidencing improvements across a number of knowledge resource foundations. Despite such progress, the industry demonstrates dynamic capabilities that are lower than the national aggregate level.

As **Figure 3.9** indicates, the food processing industry scores slightly below the national aggregate on all three components of dynamic capabilities. The level of outcomes in the form of process improvements and product-market development is also significantly lower than the Malaysian aggregate.

3.5.1 Absorptive Capability

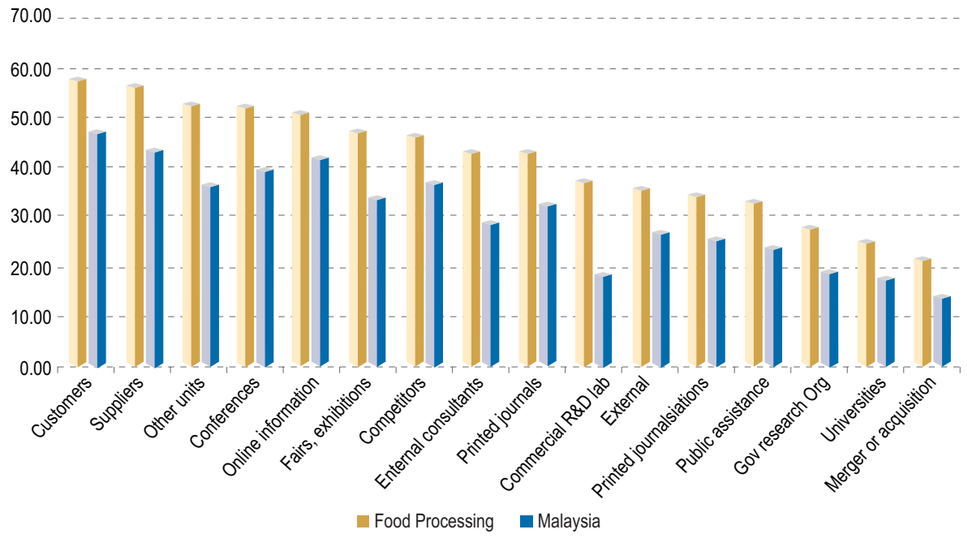
Absorptive capabilities refer to the ability to get important and relevant knowledge from external sources and then systematically store this knowledge for future use within the firm. According to **Figure 3.9**, the food processing industry is almost on par with the national aggregate performance, which is reflective of a medium level of knowledge absorption. Firms in the food processing industry are able to acquire the needed technology from external sources. However, despite showing good standing in absorptive capability they need to improve upon learning and transfer of acquired knowledge.

Figure 3.9: Dynamic Capability Profile of the Food Processing Industry



Overall, the food processing industry sources knowledge at a higher level than then the Malaysian aggregate (see **Figure 3.10**). Firms in the food processing industry benefit from the knowledge flow of a wide range of external sources, the most significant of which are consumers and suppliers. Firms in the industry also frequently use conferences, fairs, online information, and benchmarking with competitors to update their knowledge. On the other hand, the food processing industry collaborates the least frequently with government research organisations and universities.

Figure 3.10: Sources of Knowledge in the Food Processing Industry

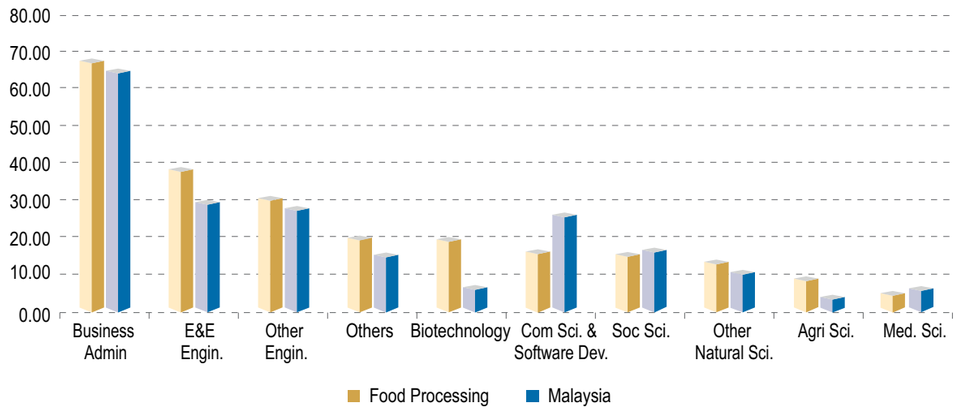


3.5.2 Adaptive Capability

After acquiring knowledge and technology, it is crucial to make use of it inside the firm. This requires adaptive capabilities which undergird the ability to develop new structures and processes around knowledge and to allocate the resources needed to make specific use of it. In terms of adaptive capabilities, the food processing industry is almost on par with the national aggregate (see **Figure 3.9**). This is promising but nonetheless the industry faces a number of challenges. For instance, many food processing firms are small players and many have difficulty finding the financial and human capital resources needed to invest in innovation projects. However, most industry players realise the need to develop their internal processes and marketing capabilities. An increasing number of firms have started to seek help from relevant government agencies and institutions, such as SIRIM and MATRADE, and upgrade their structures and processes.

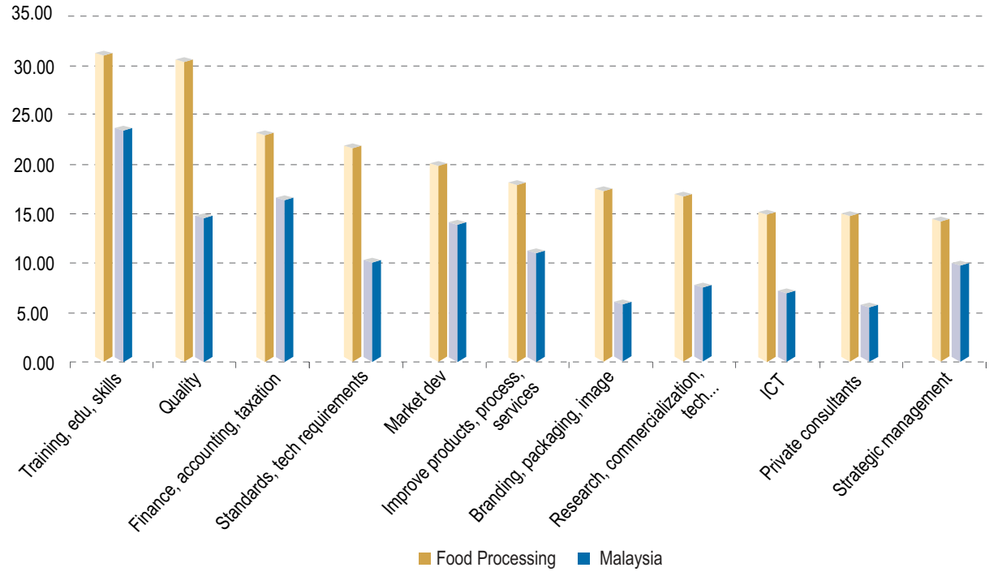
Figure 3.11 shows the skills profile of firms in the food processing industry. Business administration graduates constitute the largest group in the industry. Electrical and Electronic engineering and general engineering are the next largest groups, followed by biotechnology, computer science, social science and other natural sciences. The industry has strong presence of business and engineering skills, but a much lower level of biotechnology and food science skills. Availability of relevant skills is an important resource that enables firms to learn, understand and process external knowledge. Skills in fields such as biotechnology and food science are needed if food processing firms are to improve their adaptive capability and translate that into new and innovative products.

Figure 3.11: Skills Profile of the Food Processing Industry



Food processing firms seek support from a range of Malaysian institutions to help with capability building of the industry. government agencies, industry association, universities and other institutions provide a range of assistance and support programs. Training, educational and skill enhancement are areas in which food processing firms seek help most frequently (see **Figure 3.12**). Food processing firms also seek assistance to develop operational capability through assistance on standards and quality management. Market development, branding, and product and process improvement are also areas where firms get institutional support. Overall, the food processing industry scores higher than national aggregate in terms of the support from agencies across the full range of skill building activities.

Figure 3.12: Role of Institutional Environment in Skill Building of the Food Processing Industry

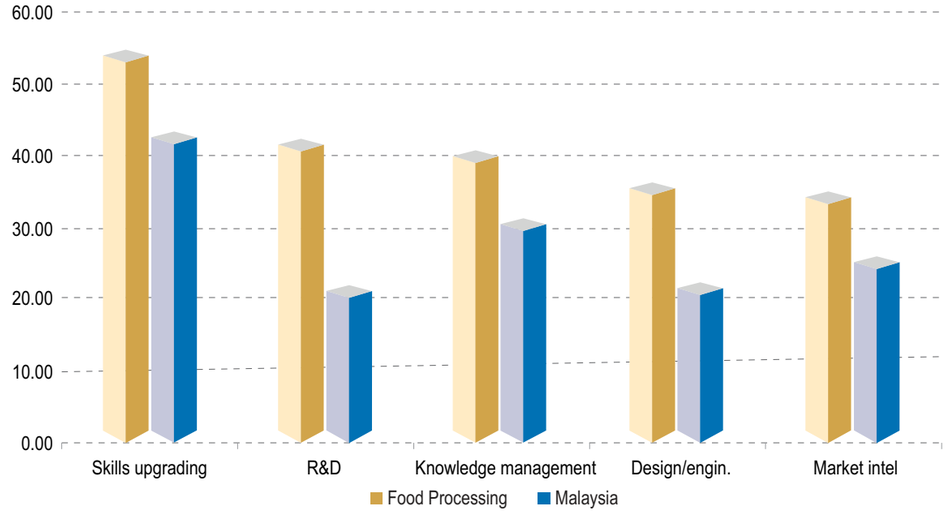


3.5.3 Innovative Capability

In terms of innovative capability, results show that the food processing industry falls just below the national aggregate (see **Figure 3.13**). Innovative capabilities entail the ability to create and implement processes that integrate knowledge and resources to take advantage of opportunities. Innovative capability in the food processing industry suggests that food processing firms are still limited in their ability to internalise external knowledge and process it in a manner that allows new product and new market venturing.

Positively, food processing firms engage in a significant level of innovative capability building activities. Food processing firms have a considerably higher level of investment in R&D activities; almost double that of the national aggregate level. Firms are also proactive in design and engineering improvements and show strong skill-upgrading activity, knowledge management, and high level of focus on market intelligence. Despite all the positive activities, the level of innovative capability remains slightly below the national aggregate level. This shows that the ability of firms in the food processing industry to leverage existing knowledge and technological capability to develop new products is weak. The lack of relevant skill-set and human capability limitations, as well as financial limitations could be factors that undermine the development of innovative capability of the industry.

Figure 3.13: Knowledge Intensive Activities in the Food Processing Industry



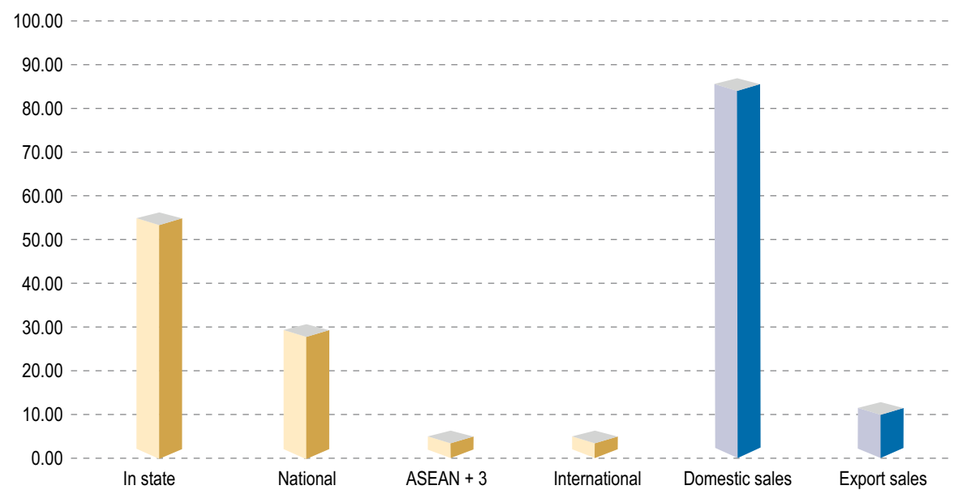
3.6 Outcomes of Dynamic Capabilities in the Food Processing Industry

Similar to many other industries, the food processing industry has a heavy domestic focus. The industry makes 87.12% of its revenue in the Malaysian market. Sales within state comprises 56.33% of revenue, indicating strong co-location influence. Total export sales are only 12.89%. Of that, the regional market (ASEAN plus Japan, China and South Korea) accounts for 6.48%, with international sales at only 6.39%.

The food processing industry exhibits below average process improvements (see **Figure 3.9**). Most of the players in food processing industry are small and mostly family-owned. Management processes are deployed in a piecemeal manner and firms show weaknesses in their marketing activities although most are starting to recognise the importance of such functions.

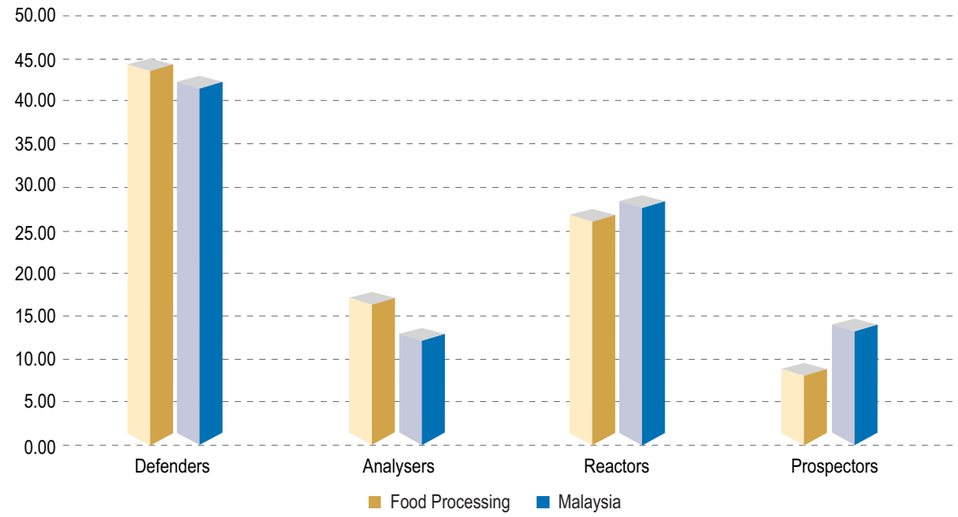
With dynamic capabilities lower than the Malaysian industry aggregate, it is no surprise to find that the food processing industry is weak in product/market development (see **Figure 3.9**). Firms in the food processing industry do not release high novelty products but simply refine/adapt existing ones for the needs and price range of the Malaysian market.

Figure 3.14: Market Presence of the Food Processing Industry



Note: The results are based on survey data.

Figure 3.15: Strategic Profile of Firms in the Food Processing Industry



The strategic profile of firms in the food processing industry shows dominance of Defenders (45.22 %), refer to **Figure 3.15**. The second largest group is Reactors (27.39%). Reactor firms are backward looking companies that fail to make adequate adjustment to changed environment. Analysers account for 17.83% and are risk-averse firms. The smallest group in the food processing industry is the Prospectors. Prospector firms are the market innovators as they take risks by making investments in potentially high pay-off products or services of the future.

The food processing industry has higher number of Defenders and Analysers compared to national aggregate level, and lower number of Reactors and Prospectors compared to the Malaysian industry aggregate. Unfortunately, the industry has only 9.5% of Prospector firms. This is indicative of weakness within food processing, since such firms are the creators of strong innovation spill-overs in the economy.

3.7 Relationships between Key Blueprints of the Food Processing Knowledge Ecosystem

This section examines the impact of knowledge enablers on dynamic capabilities, and the economic outcomes for the food processing industry. The knowledge ecosystem for the food processing industry in Malaysia is compared against that of advanced sector countries (Brazil, Russia, and United States). Content analysis and data acquired from DOS shows the food processing industry to be a Pace-setter in Malaysia, or one that is governed by high level of knowledge content and innovations.

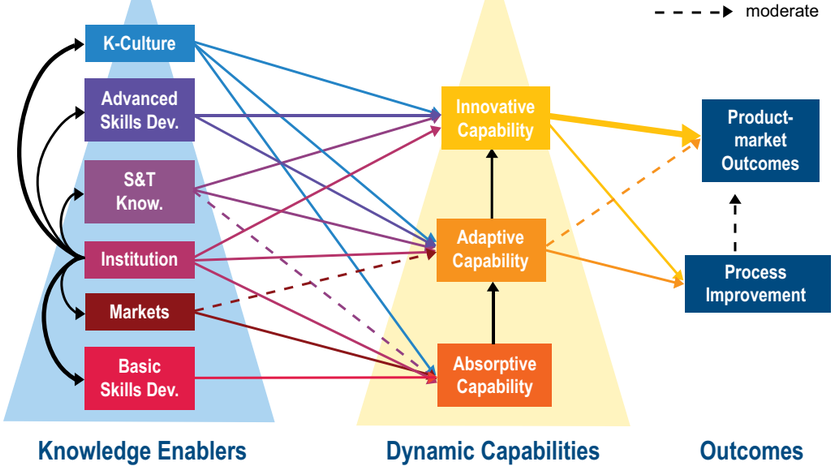
The knowledge ecosystem for the food processing industry in advanced sector countries is presented in **Figure 3.16**. In advanced sector countries, the knowledge ecosystem for firms in the food processing industry supports all three components of the dynamic capability (i.e. absorptive capability, adaptive capability and innovative capability). This strong capability set, in turn, enables strong outcomes in the form of both product and process innovations. Food processing firms in these countries possess a very strong foundation in absorbability capability by being keenly aware of changing

consumer trends. They align their internal structures and processes through effective adaptive capability, and coupled with absorptive capability endow strong innovative capability to produce higher value-added innovations.

Based on the data obtained from DOS, the knowledge ecosystem for the food processing industry in Malaysia is shown in **Figure 3.17**. From the figure, it is observed that the knowledge ecosystem for firms in this industry is relatively weaker than that of advanced sector countries. There are a number of differences between the ecosystem in advanced sector countries and in Malaysia. One interesting and notable difference is that the impact of S&T knowledge on innovative capability in advanced sector countries is positive and. In contrast, Malaysia's ecosystem exhibits a negative impact on innovative capability. This observation suggests an opportunity cost that possibly arises as a consequence of high investments that create low level S&T competencies and an absence of sustained R&D activity among Malaysian firms. As **Figure 3.17** illustrates, there are many differences, particularly the lack of influence of enablers on dynamic capability building processes.

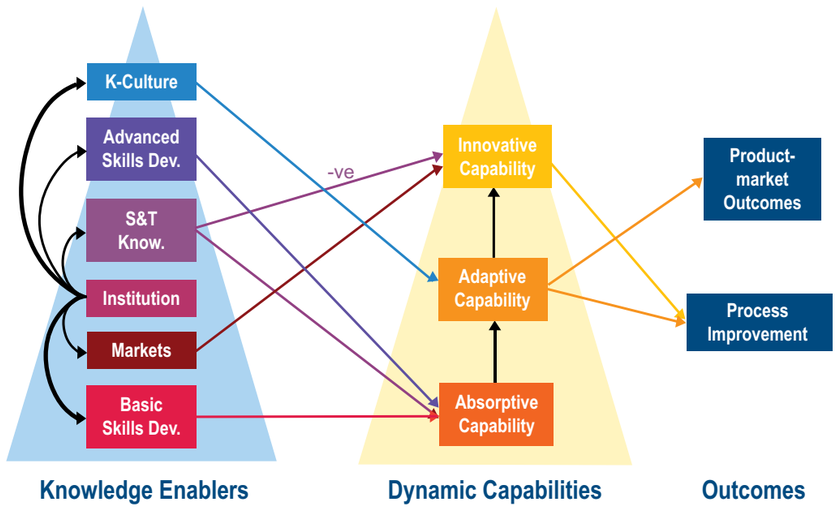
While the knowledge ecosystem in the food processing industry in Malaysia supports all three dynamic capability components, these capabilities appear to only enhance process improvement (see **Figure 3.17**). Nonetheless, there are instances where flows arising from adaptive capability yield some product market outcomes. This is observed in the release of niche products serving local needs, such as Halal certified foods or locally available organic herbs, fruits and spices.

Figure 3.16 Knowledge Ecosystem of the Food Processing Industry in an Advanced Country



Note: Very strong impacts are represented by the bolded line, strong impacts are represented by normal lines and moderate impacts are represented by dotted lines.

Figure 3.17 Knowledge Ecosystem of the Food Processing Industry in Malaysia



A summary of strengths of the food processing knowledge ecosystem in advanced sector countries and in Malaysia is provided in **Table 3.3**. Comparison of the two knowledge ecosystems indicate that the food processing industry in Malaysia is relatively weaker than that of advanced sector countries.

Table 3.3: Knowledge Enablers and Dynamic Capabilities for the Food Processing Industry

Advanced Countries	Malaysia
Basic skills have a **positive and strong impact** on absorptive capability. The food processing industry in advanced sector countries possess sufficient basic skills. The basic skills are highly flexible and capable of being trained for higher skills. Skills building is conducted by a range of initiatives driven by government agencies, regulatory authorities, industry associations and institutions of learning. This creates a strong foundation of basic skills that can be leveraged to good effect.	Basic skills have a **positive and strong impact** on absorptive capability. Similar to the advanced sector countries, basic skills building takes place through the actions of numerous agencies, ranging from initiatives instituted by government bodies to training by the firms themselves. In the food processing industry in Malaysia, the role of regulatory bodies is to ensure compliance of food products to international standards, such as HACCP and ISO standards. Additionally, Malaysia leads in Halal standards. Compliance is critical for operations, and also helps ensure continuous upgrading of basic industry-relevant skills.
Market intelligence has a **positive and strong impact** on absorptive capability, and **positive and moderate impact** on adaptive capability.	Market intelligence has a **positive and strong impact** on innovative capability.

Table 3.3: Knowledge Enablers and Dynamic Capabilities for the Food Processing Industry (cont'd)

Advanced Countries	Malaysia
Suppliers, customers, competitors, external consultants, and commercial R&D centres in advanced sector countries contribute to the strong absorption of new knowledge, particularly the use of new technology, systems and processes to develop new, efficient and cost-efficient products for the food processing industry. Consumer needs in advanced sector markets change rapidly with lifestyle shifts, and advances in food technology enable increasing level of innovation to keep with pace with the change in needs. Convenience in food remains a major factor, but consumers are increasingly demanding freshness and healthy food options.	Large food processing firms, especially MNCs, feature strongly in driving the domestic market. They utilise the parent company's R&D expertise to create products to suit local tastes. Local companies innovate based on their detailed knowledge of local tastes and history of cuisine. Most often, local firms undertake incremental innovations. The vast majority of local firms operate in cost sensitive markets, and find it difficult to create high value brands that can target markets globally. Niche areas, such as the Halal market, offer significant opportunities for growth, but local firms lack resources and market capabilities to fully leverage upon this.
Institutions are **strong enablers** of the knowledge ecosystem and have a **direct strong and positive impact** on absorptive, adaptive and innovative capabilities. Institutions, such as regulatory authorities setting manufacturing standards, industry associations and universities, play an important role in creating a vibrant ecosystem. Specialists in food science, culinary and hospitality schools as well as strong manufacturing capability through high-level engineering science create strong impetus in creating high intensity in dynamic capabilities components. They contribute to producing new and novel products in the food processing industry through new packaging, improved preservation and higher nutritional content.	Institutions are strong enablers for other knowledge enablers, but they do not impact absorptive, adaptive and innovative capabilities directly. Regulatory institutions, such as MOH, MITI, FAMA, SIRIM and MATRADE, play a key role in regulating the food processing industry. They initiate various programmes to improve competitiveness of local firms through compliance with international manufacturing standards. Industry associations and universities provide manpower training for the food processing industry. However, these institutions lack specialists, and thus they are unable to directly influence the development of dynamic capability components of firms in the Malaysian food processing industry.
S&T knowledge has a **positive and moderate impact** on absorptive capability, and a positive and strong impact on adaptive and innovative capabilities. Scientific advancement is a key feature of the industry. It ranges from advances in packaging and production machinery to food processing technologies and food nutrition. Knowledge in these areas and their applications contributes to	S&T knowledge has a **positive and strong impact** on absorptive capability. However, S&T knowledge has a **negative and strong impact** on innovative capability, which shows that **S&T knowledge has an opportunity cost** to the innovative capability of the food processing industry. Most firms in the Malaysian food processing industry are users of new technology and innovations. S&T knowledge in the industry is used to learn about existing technical knowledge, and thus, there is direct link to absorptive capacity, rather than

Table 3.3: Knowledge Enablers and Dynamic Capabilities for the Food Processing Industry (cont'd)

Advanced Countries	Malaysia
the continuous stream of innovations in the food processing industry in advanced sector countries. The industry is able to bring together a complex set of multi-disciplinary skills, and is rich in strong engagement with both upstream and end consumers.	a feed into higher level dynamic capabilities, as observed in advanced sector countries. S&T in the Malaysian food processing industry remains in an infant stage. Without substantive R&D, there is fragmentation that may develop into an opportunity cost.
Advanced skills have **a positive and strong impact** on innovative and adaptive capabilities. Significant resources are channelled to increase the quantity and quality of individuals with advanced skills that are relevant for the food processing industry in advanced sector countries. Research degrees are highly focussed, and this produces competent people who are at the forefront of their respective fields of endeavour. The requisite level of skills, infrastructure and investments are fostered through a strong 'quadruple-helix' that brings together all key pieces of the jigsaw for innovation.	Advanced skills have a **positive and significant impact** on absorptive capability, but not on innovative capability. Quantity and quality of knowledge within the Malaysian food processing industry is improving and on an upward trend. However, there is insufficiency in the level of advanced skills and a weak integration of knowledge from diverse areas needed to create full capability within the food ecosystem. Thus, the industry is primarily focussed on using new technology and innovations rather than creating novel advances in food processes and product-market outcomes.
Knowledge culture has a **positive and strong impact** on absorptive, adaptive and innovative capabilities. Organisational culture of firms in the industry for advanced sector countries is heavily focused on innovation across a diverse range of areas that are industry relevant. Innovation is focussed on new products and process improvement for efficient high value manufacturing. Innovation is everyone's concern and not just of the R&D departments or senior management team. All functional departments are considered an integral part of the innovation agenda. Both incremental and radical innovations are highly valued for their contribution to the success of the firm.	Knowledge culture has a **positive and strong impact** on adaptive capability only. Organisational culture of most firms in the Malaysian food processing industry is predominantly hierarchical, and R&D activities are primarily undertaken by a few people or a specific department within the firm. Many firms do not invest resources for R&D as they prefer to rely on knowledge and technology from advanced sector countries. There is also a strong 'top-down' culture in which the prerogative to innovate is the domain of a few key individuals. The major focus is to improve processes through TQM-based approaches.

Table 3.3: Knowledge Enablers and Dynamic Capabilities for the Food Processing Industry (cont'd)

Advanced Countries	Malaysia
Continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** Rigorous R&D and a strong and competent workforce with basic, technical and R&D skills and experience contribute to the industry's capability in remaining resilient in absorbing new knowledge. Strong foundational knowledge contributes to food processing firms' ability to adapt external knowledge and reconfigure such knowledge into new innovations that improve food processing processes and enhance the quality of existing food products. Possessing extensive experience, workers in this industry in advanced sector countries are able to translate theoretical knowledge into new food products and efficient manufacturing systems.	Continuum from absorptive capability to adaptive capability to innovative capability **is present.** Skilled workforce in the Malaysian food processing industry is characterised with a capacity to adopt new knowledge generated from advanced sector countries. Some level of refinement and modification takes place to accommodate local food tastes and requirements. The Malaysian food processing industry has, in recent times, demonstrated some leadership in niche areas, such as Halal and locally available varieties of food.

A detailed assessment between the flows from dynamic capabilities to economic outcomes in the food processing industry for both advanced sector countries and Malaysia are summarised in **Table 3.4.** Findings from the study suggest that the impact of dynamic capabilities on economic outcomes for the food processing industry in advanced sector countries and in Malaysia vary across a number of fronts. For advanced sector countries, adaptive capability has a positive and strong impact on process improvements as well as a positive and moderate impact on product market outcomes. Innovative capability has a positive and strong impact on process improvement and a very strong impact to product market outcomes.

In the case of the Malaysian food processing industry, adaptive capability has a strong and positive impact on both process improvement and product-market outcome. Innovative capability, on the other hand, only contributes to process improvements. This is indicative of poor product innovation and penetration of international markets. Products manufactured by the vast majority of local food processing firms are driven by price differentiation rather than strong brand differentiation. Nevertheless, some level of differentiation is present, such as Halal certified products. With appropriate market and manufacturing strategies, such niche offerings have the potential to become global brands.

Table 3.4: Dynamic Capabilities and Economic Outcomes for the Food Processing Industry

Advanced Countries	Malaysia
Adaptive capability has a **positive and strong impact** on process improvement and a positive and moderate impact on product market development. Firms in the food processing industry in advanced sector countries are strong in adapting new technology and innovations to make continuous improvements in the processing and production of food products for local and global markets.	Adaptive capability has a **positive and strong impact** on process improvement and a **positive and strong impact** on product market development. Adaptive capability of firms in the Malaysian food processing industry is developed by leveraging on existing knowledge from advanced sector countries. This creates the basic building block on which the domestic food processing can begin to develop a capability to exploit niche food areas. In niche food markets, such as Halal, local herbs and tropical fruits, Malaysian firms are able to exert some form of innovative leadership. Unfortunately, such leadership is often not sustainable without strong brand and market capability, even when food products are high in quality.
Innovative capability has a **positive and strong impact** on process improvement and a **positive and very strong** impact on product market outcomes. Strong innovative capability backed by sound S&T base, high R&D investment and presence of a strong quadruple-helix contribute to the emergence of new food processing machinery and instruments, applications, products, and services. Possessing a full set of components within their industry supply chain, food processing companies in advanced sector countries are able to release a raft of product innovations that embody these advances.	Innovative capability has a **strong impact** on process improvement. New technology, systems, processes and management tools in the Malaysian food processing industry are adopted from advanced sector countries. Much effort is put into learning to use foreign technologies to manufacture to the required standards in a cost-efficient manner. Little time or attention is allocated to product-market innovation.
Process improvement produces a **positive and moderate impact** on product-market outcomes. Sound enabling factors create a sound base of dynamic capabilities. They engineer process improvements that lead to enhancement of the product portfolio in the food processing industry in advanced sector countries.	Process improvement **does not impact** product market outcomes. Process improvements in the Malaysian food processing industry are highly dependent on the use of foreign technology, knowledge and intellectual property. This dependency and the lack of knowledge limits Malaysian firms' ability to create improvements in their products beyond lowering their cost of production.

3.8 Summary: Key Trends, Challenges, Way Forward and Best Practices

3.8.1 Industry Trends

The food processing industry shows a number of positive developments in its knowledge foundations. In 2014, almost all elements of knowledge foundations in food processing industry scored above or at least on par with the Malaysian industry average. SMEs make up about 80% of the industry, and the overall dynamic capability is slightly below the national aggregate across all components of dynamic capabilities. Outcomes in the form of processes or product-market development are also significantly lower than the Malaysian industry aggregate. Nonetheless, Malaysian food processing industry players have taken note of the need to build stronger knowledge and innovation capability. An increasing number of firms have started to invest in improving their knowledge base. Many government agencies, such as MOH, MITI and FAMA, provide help to spur growth and innovation in the food processing industry.

Although Malaysia has sizeable agriculture industry, the food processing industry still relies heavily on imported raw materials. The agriculture industry, especially the crop-based industry, is beginning to show promise. As agriculture grows, it opens up huge growth prospects for the food processing industry. Additionally, Malaysia is at the vanguard of Halal standard and certification. This provides Malaysian food companies an exceptional opportunity to capitalise on the country's globally accepted and recognised Halal logo and standards to penetrate global markets.

3.8.2 Challenges

The Malaysian government has introduced and implemented several projects to develop the food processing industry. However, the industry in building knowledge content faces a number of key challenges.

Institutions:

- Demand conditions and changes in food consumption patterns are changing at a rapid pace in Malaysia and across the globe. Lack of coordination and cooperation among key institutions has resulted in ad hoc strategies and policy implementation; resulting in a national food processing ecosystem and industry that are relatively weaker than that of more developed countries.

- Key government institutions, industry associations and universities play a key role in establishing the regulatory standards, manpower training and rules for foreign direct investment and other industries policies. However, these policies are often uncoordinated, creating gaps in the ecosystem. Fragmentation of the upstream and downstream industries in the agriculture industry is further exacerbated by poor transportation infrastructure. Hence, the food industry is unable to derive the multiplier effect, economies of scale and scope.

- SMEs lack the resources to take advantage of the support provided by government agencies due to uncoordinated programmes and overly bureaucratic, cumbersome and complicated systems, rules and processes.

Basic Skills Development:

- Most of the workers, especially in the SMEs lack English language proficiency. This hinders their ability to access new S&T knowledge and innovations.

- Cost of training is very high and many SMEs do not invest in capability development programs.

- High staff turnover due to low pay, talent poaching and over reliance on cheap foreign workers.

- Lack long-term skill enhancement plan due to uncertainty and rapidly shifting technology, market demand conditions and global standards for food safety and nutrition.

S&T Knowledge:

- S&T knowledge used by most local firms relates to learning about existing technical knowledge. IPs is primarily owned by foreign firms, and thus foreign S&T knowledge is used to improve existing production processes in local firms.

- Many of the SMEs use old equipment and technology. This adversely impacts their efficiency, productivity and competitiveness vis-à-vis counterparts from more developed countries.

- Local S&T knowledge remains at an infant stage due to lack of investment in R&D and capability development programs.

- Weak knowledge base for the food processing industry, specifically in food science and food manufacturing due to lack of expertise in the country and the cost of acquiring foreign talent remains expensive.

Advanced Skills Development:

- One of the major challenges encountered by the industry is the lack of workers with advanced knowledge and skills set in key areas within the food processing industry.

- Weak integration of knowledge from diverse areas and weak collaboration between industry and universities hinders the industry from developing innovative processes, systems and other creative endeavours that are vital for moving the industry up the knowledge value chain.

- Industry is primarily focused on using new technology and innovations rather than creating novel advancement in the food processing field; hence, most of the skills development and training programs are to ensure workers have the capacity to use these new technologies for improving the production processes in the industry.

Market Intelligence:

- Local firms, especially SMEs are not well linked to research organisations, networks and content providers – this prevents them from gaining access to valuable information on new scientific discoveries and innovations.

- Many of the SMEs are not tech-savvy and do not use ICT. This limits their market opportunities. Hence, many firms become dependent on their suppliers for market intelligence.

- Vast majority of local firms operate in cost sensitive markets, and find it difficult to create high value brands that can target markets globally.

- Niche areas such as the Halal market, offer significant opportunities for growth, but local firms lack resources and market capabilities to fully leverage upon the global halal industry.

- SMEs in the food processing industry are not ready to export their products. They find it difficult to penetrate the foreign markets due to their inability to meet the food quality standards and understand the local regulations and cultures of international markets.

Knowledge Culture:

- Organisational culture of most firms in the Malaysian food processing industry is predominantly hierarchical, and R&D activities and attitudes are primarily undertaken and espoused by only a few people or a specific department within the firm.

- Most local firms are risk averse in undertaking R&D activities, because it is expensive and uncertain in yielding any positive outcomes; hence many do not invest resources for R&D activities. Many prefer to rely on knowledge and technology from foreign firms from more developed countries.

3.8.3 Way Forward

The demand for process food products has been on an upward trend due to changing lifestyles and dietary preferences of consumers in Malaysia and globally. To capture a more significant portion of the national and global market share, local firms will have to be competitive. To do so they will have to build their knowledge capabilities and innovative capacity. Key strategies to enhance the knowledge intensity of the Malaysian food processing industry are discussed below.

Recommendation 3.1: Focus Strategy to Improve Innovation and Competitiveness of the Industry

- Develop a 5-year master plan in partnership with industry associations, GLCs, MNCs and SMEs to provide a systematic framework for the closer linkage between the agricultural and food processing industry by incorporation of Industry4.0.

- The plan should have clear targets, KPIs, milestones and accountability to raise the level of innovation, competitiveness and market development. This will require making available the resources and support systems needed by stakeholders in the agriculture and food processing industry.

- The plan should address key R&D focus areas and technologies that need to be developed locally; and innovations should be imported from leading foreign countries.

- Refine key terms of reference of key institutions and develop new institutions to coordinate the development of the industry by continuously tracking the KPIs and ensuring they meet the desired target of transforming Malaysia into a leading food processing hub in the region.

Recommendation 3.2: Holistic Talent Development Strategy

- To reduce the reliance on cheap foreign workers, there should be support for firms, especially SMEs, to upgrade and automate their technology and systems to transform labour intensive tasks to more technology and knowledge intensive operations. The support can be rendered through technology grants, subsidies and expert advice on strategy and marketing implementation and mentorship.

- Increase the number of programs in colleges, polytechnics and universities on agri-food and food-processing, with strong internship and work placement programs. These programs should be certified by a professional industry based council, similar to the *Canadian Food Processing Human Resources Council,* comprising leading food manufacturers on the board.

Recommendation 3.3: Intensify Basic and Translational R&D

- Establish National Food Processing Research and Training Centre that will help Malaysia increase its global competitiveness in the food production areas through developing innovative purification and extraction processes: processes that are energy efficient, reduce waste materials, and are environmentally friendly.

- This centre should also undertake novel biotechnology R&D to improve shelf-life of food products without the need for chemicals and preservatives.

- These new R&D in innovative bioprocessing should lead to new innovative and high value products that enhance the quality of agriculture, dairy and the neutra-ceutical industries, leading to healthier diet for consumers in the region.

- This centre should be a partnership between a leading research university and a consortium of food manufacturers and producers.

- Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs should be introduced. There should be modelled after the programs in USA where research and technology transfer support is provided to SMEs via leading research universities and centres.

- Universities and research centres should be encouraged to spawn 'start-up' companies that undertake innovative processes and products that enhance the local food processing value chain.

Recommendation 3.4: Develop a Business Friendly Food Processing Ecosystem

- Develop a 21st century logistic network that creates a seamlessly integrated logistics supply chain connecting the upstream and downstream agriculture industry, as well as linking local producers and manufactures to the global food supply network.

- Government agencies need to study and identify synergies between food processing and agriculture industries so that local food processing players have ready access to local high quality raw materials.

- Provide training and assistance to local producers on internationalisation strategy, including knowledge on international standards and certifications, such as Good Manufacturing Practice (GMP), Hazard Analysis and Critical Control Points (HACCP) and Halal standards.

- Provide financial support and assistance for SMEs to translate their innovations into patents that enable them to get better value for their IPs.

- Relevant government agencies, such as MATRADE and embassies, can consider offering assistance and support beyond business matching such as extended services to facilitate business development in overseas markets.

- Establish a one-stop business centre that offers shared facilities for Malaysian businesses to meet with overseas clients. This will be useful for expediting business development of SMEs.

3.8.4 Best Practices

Modern agronomy, automation and technological developments have in many cases increased the production of processed food. In this section, a range of best practices that have assisted global food processing countries to improve their knowledge intensity and innovative capability are presented.

Best Practice 3.1: Focus Strategy to Improve Innovation and Competitiveness of the Industry

Agriculture and Agri-Food Canada: Value-Added Agriculture and Agri-Food Processing Industry – Growing Forward 2 Program

- The food processing sector is the second largest manufacturing industry, largest employer within the manufacturing industry and the biggest industry that purchases agriculture products in Canada; hence a strategic development plan is in place to strengthen the industry to be a global leader in food processing. This plan is to achieve the following:

- Increase the reach of the industry in both domestic and international markets;
  - Increasing the competitiveness and competitive advantage of the industry by using advances in science, technology and innovation; and adoption of global best processes, practices and standards including risk management, ensuring economic and environmental sustainability and gaining public trust and confidence in the sector; and

- the plan also clearly articulates the KPIs, measurable targets, agencies responsible and mechanisms for tracking performance against established targets.

- Key strategies to raise the competitiveness of the Canadian food processing ecosystem are:
  - Forums for government and industry to work closely to develop strategies and policies to address the changing needs of local and international markets;
  - Provide business development activities for local food processors to enhance market opportunities, profitability and resilience;
  - Continuously review the regulatory framework to ensure that local businesses adhere to global best practices and standards in order to be globally competitive;
  - *Agricultural Greenhouse Gases Program:* Provides funding and support for business to use modern technology that is environmentally friendly, efficient and competitive;
  - *Agricultural Youth Green Jobs Initiative:* Provide support to ensure sustainable internship and post-secondary graduate training programs in order to provide industry-relevant skills to next generation workers for the industry;
  - *Agri-Food Trade Service:* This is a "one-stop Centre" providing access to market intelligence, trade counselling and export support.
  - *Agri-Innovation Program – Industry led R&D stream*: Funding to support for R&D and knowledge transfer for innovative agriculture, agri-food, agri-based practices and products;
  - *Agri-Innovation Program – Enabling Commercialisation and Adoption Stream:* Funding and support for firms and cooperatives for pre-commercialisation, commercialisation and adoption of innovative agri-based products, technologies, processes and services;
  - *Agri-Marketing Program:* Funding support for non-profit organisations and SMEs for promotion, branding and market development activities;
  - *Canada Brand Program:* Firms, industry association, farming organisations, food processors have access to various marketing tools and support services to help professionalise their branding efforts;
  - Other services available for the food processor and manufacturer include financial loans for business development, access to animal genetics materials, government funded internship program, debt mediation service, access to scientific equipment and expertise via the Food R&D Centre's Industry Program, Geospatial information, support for R&D and IP/patent filing. (Agriculture and Agri-Food Canada, 2016)

Best Practice 3.2: Holistic Talent Development Strategy

The Canadian Food Processing Institute, Food Processing Human Resources Council (FPHRC)

- FPHRC is a non-profit council established in 2009, comprising major food processing industry leaders on the board of FPHRC, who ensure that the workers in this industry have access to state-of-the art training and educational programs that will enhance the global competitiveness of the industry.

- The FPHRC has also developed a competency framework to professionalise the workforce and create career path for workers in this industry.

- The Institute has designed courses and training programs using a variety of affordable leaning tools (e-learning platforms) and competency in the courses are continuously enhanced to ensure that the workforce has the necessary skills and knowledge to make the industry a global leader in food processing.

- The FPHRC/Institute also provides training, certification and accreditation services on various global standards and best practices such as the Global Food Safety Initiative (GFSI), HACCP, BRC, SQF and Canada GAP. (Food Processing Human Resources Council [FPHRC], 2016).

Best Practice 3.3: Intensifying Basic and Translational R&D

The Australian Research Council Training Centre for Food Processing Industry in the 21st Century at the University of Sydney:

- The Centre is a unique collaboration between University of Sydney researchers from the faculties of Engineering and Information Technologies, Agriculture, Science, and Medicine and international biotechnology companies that push the frontier of knowledge in the field from a multidisciplinary perspective.

- The Centre is an important support for the industry adopting leading-edge scientific discoveries, engineering methods and designs for the food processing industry to reduce cost, be environmentally, adhere to global best practices and be competitive in the global food industry.

- The Centre focuses R&D in areas that are strategic to the Australian food processing industry, such as process optimisation and biotechnology, which leads to following:

- Quality research in high value food products that are safe, healthy and will prevent and treat various chronic diseases.

- Discovery of cost effective ways of producing minerals, food produce that uses less energy, is environmentally friendly and reduces waste. Identification of new techniques and methods to reduce spoilage and increase shelf-life of perishable food and products.

  The Centre also conducts training and workshops for next generation experts and talent in food technology and manufacturing; and transfers knowledge and technology to local industry. (The University of Sydney, 2016)

Best Practice 3.4: Developing a Business Friendly Food Processing Ecosystem

The US Cold Chain System

- The cold chain system is crucial for perishable food products that are transported across the globe. USA has one of the most sophisticated transportation and logistics network system (road, rail, air and sea) equipped with temperature controlled containers and facilities using advanced technology and GPS system.

- The US has the largest cold 3rd Party Logistics (3PLs) sector – 3PLs provide a system to integrated warehousing and transportation services to businesses on an outsourced basis, with extensive reach in other continents. The latter helps American food producers extend their market reach to the global community in an efficient and punctual way.

- United Parcel Services (UPS) and FedEx are one of the top 3PL service providers with in-house custom clearance to ensure smooth international deliveries of perishable goods and reduction in risk of damage to these fragile goods.

- US also has a network of companies that produces temperature control systems for trucks (called reefers), trailers, rail cars and shipping containers that are seamlessly connected to one another. This enables fragile products to be smoothly transported via multiple transportation modes. These sophisticated transportation systems have sensors and advanced communication and GPS systems to continuously monitor the temperature of the containers to ensure they are at an optimal temperature for the cargo.

- The sophisticated cold chain system in the USA is also attributed to the strong collaboration among industry, government, trade/industry associations and enforcement agencies in ensuring the following: transparent policymaking; strong technical regulations, standards and procedures for ensuring highest service quality; zero-tolerance for rent seeking and moral hazard behaviour; and, a legal system that enable firms to resolve legal disputes quickly.

- There is also a steady supply of talent and adequate training to continuously upgrade skills of people working in the cold chain systems.

- The infrastructure to support the cold chain system is reliable, sound and continuously upgraded as new technology emerges to support the system.

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CHAPTER 4

KNOWLEDGE CONTENT OF THE CHEMICALS, PETROLEUM AND PHARMACEUTICALS INDUSTRY

CHAPTER 4
Knowledge Content of the Chemicals, Petroleum and Pharmaceuticals Industry

4.0 Introduction

The chemicals, petroleum and pharmaceuticals industry is a key component of the Malaysian economy. It is composed of three distinct industry components: despite the connection between the three industries, each has its own specific dynamics and qualities.

4.0.1 Chemicals Industry

The chemicals industry is one of the leading and most developed industries in Malaysia. It is the second largest contributor to the country's total exports of manufactured goods (MATRADE, 2016a). The chemicals industry consists of various sub-industries, including oleochemicals, petrochemicals, and agriculture chemicals. The Malaysian chemicals industry is particularly advanced in petrochemicals and oleochemicals due to the abundance of raw materials (palm oil and natural gas/petroleum). The strength is evident through continuous growth rate of exports in both petrochemicals and oleochemicals (see **Table 4.1**). The chemicals industry is also important to overall industrial development. There is hardly any industry where chemical substances are not used; this list includes variously the agriculture, automotive, electrical and electronics, pharmaceuticals, construction and petroleum industries. The role of chemical processing in generating innovation for other industries is therefore substantial, whereby technological innovation in the chemicals industry leads to a positive spill-over effect into other industries.

Table 4.1: Continuous Growth in Chemicals Exports in 2015

Food	2015		2014			
	Million (RM)	Share %	Million (RM)	Share %	change (value)	Change %
Total exports of chemicals	51,446.90	100.00	55,142.40	100.00	3,695.50	7.20
Petrochemicals	22,153.40	43.10	23,393.30	42.40	1,239.90	5.6-
Oleochemicals	12,094.10	23.50	12,278.60	22.30	184.40	1.50

Source: MATRADE (2016a)

The government's concern about developing the oleochemical industry led to the initiation of Entry Point Project 6 under the Economic Transformation Program with the aim of steering Malaysia's downstream palm oil industry towards the production of higher value oleo-derivative products and bio-based chemicals. According to ETP Annual Report (2014), since the start of EPP 6, a total of RM1.35 billion was invested by seven companies, namely Kuala Lumpur Kepong Berhad, Emery Oleochemicals Berhad, IOI Berhad, Ancom Crop Care Sdn Bhd, ICM Speciality Chemicals, Carotino Bhd and Uni Oleon Sdn Bhd. The investment is meant to develop plants and factories that specialise in producing high-value oleo derivatives, such as surfactants. The development of higher-value oleo derivatives, the eco-friendlier alternative to petrochemicals, can also help the growth of downstream industry while protecting the upstream industry from volatile commodity price shocks.

Developing the petrochemical industry is also a priority for Malaysia's economic development. The new refinery and petrochemical integrated development (RAPID) project in Pengerang is expected to create radical change to Malaysia's and South East Asia's chemical industry. As announced by PETRONAS, the project has an estimated cost of US$16 billion in addition to US$11 billion of investments for associated facilities.

4.0.1.1 Oleochemicals

Malaysia is a dominant player in the global oleochemical industry, being the world's second-largest producer and exporter of palm oil and palm oil-based products (ETP Annual Report 2014). The country is also commensurately strong in oil palm research. The establishment of the Advanced Oleochemical Technology Centre (AOTC) as part of PORIM (Oil Palm-Based Oleochemical R&D Centre) shows the government's effort to boost market-driven R&D and to address the key challenges for the oleochemical industry, the latter being the development of the down-stream derivatives and palm-based active ingredients in addition to new application of palm oil in consumer goods.

As a renewable resource that can substitute petrochemicals in many applications, oleochemicals have tremendous demand potential. However, Malaysia's oleochemical domestic market remains fairly small. The majority of oleochemical production is exported to American and European companies, such as Unilever, Nestle and P&G, to manufacture numerous finished consumer goods. This demonstrates that further growth opportunities are present through the development of the domestic manufacturing industry for finished consumer goods.

4.0.1.2 Petrochemicals

The steady growth and development in the petrochemicals industry is driven by a concerted national effort to turn Malaysia into a hub for the petrochemicals industry and for the ASEAN market. The industry has benefited from Malaysia's strategic regional location, better infrastructure compared to many neighbouring countries, collaborations with multinational petroleum companies which operate in Malaysia, and well-established integrated petrochemical zones that contain crackers, syngas and aromatics facilities. Three integrated zones are already established in Kerteh, Terengganu; Gebeng, Pahang; and Pasir Gudang/Tanjung Langsat, Johor. The wide range of petrochemicals produced in Malaysia contribute significantly to the development of the local downstream plastic industry, making it one of the most dynamic industries in the country's manufacturing industry. Furthermore, with the full implementation of AFTA, greater regional opportunities will be available for Malaysia's petrochemical manufacturers, who will benefit from access to the Asia pacific market, especially China, which remains a net importer of petrochemicals.

4.0.1.3 Agrochemicals

Despite Malaysia's strong performance in oleochemicals and petrochemicals, the market for agrochemicals remains highly consolidated and controlled by dominant multinational players that account for 75% of total market share (e.g., Bayer, Du Pont, Dow, Monsanto) (Persistence Market Research, 2014). Given the considerable growth in demand in Southeast Asia's agriculture industry, there is a large avenue for potential growth through the agrochemicals market. However, market consolidation by top multinational chemical companies makes it very hard for local business to penetrate the market. Another limitation for local players is that the domestic market for chemicals remains relatively small. Most local agrochemicals companies are domestic-centric and have allow production capacity overall. This stands in the way of achieving economies of scale. In addition, plantations are diversifying their business and engaging in the production of fertilisers and pesticides, making it difficult for some chemical companies to retain their market share. In order to increase their competitive capabilities, local businesses need to reposition themselves and offer specialised and differentiated products.

4.0.2 Petroleum Industry

Malaysia's national petroleum corporation, PETRONAS, was incorporated in 1974, and plays a major role in driving and developing the industry. PETRONAS has been entrusted with the task of helping local companies build their capability across the oil and gas value chain. Over the years, PETRONAS has grown into a fully-integrated oil and gas entity engaged in both upstream and downstream industries. PETRONAS is ranked among the Fortune Global 500 companies and has operations in more than 20 countries through an excess of 100 subsidiaries and associated companies.

According to U.S. Energy Information Administration (2016; 2014), Malaysia is the world's second-largest exporter of liquefied natural gas (LNG) and the second-largest oil and natural gas producer in Southeast Asia. In Asia Pacific, it is placed fourth after China, India and Vietnam in terms of oil reserves. Malaysia aims to become a hub for regional oil trading and storage. To achieve this goal, the Malaysian Government has invested in a number of projects to increase refining and storage capabilities. For example, once completed, the new Pengerang Independent Terminals Sdn Bhd (PITSB), which is a private-public partnership with Johor State Government, will make available 1.3 million cubic meters of storage (ETP Annual Report, 2014).

In recent years, there has been a decline in Malaysia's production capacity in major producing oil fields, many of which are offshore. Meanwhile, domestic oil consumption has risen, thus sharply reducing the gap between oil imports and exports. This has led the government to double its efforts in encouraging investments into deep-water fields and Enhanced Oil Recovery (EOR). To this end, PETRONAS is conducting a number of EOR projects to extend the production life of Malaysia's oldest oil fields. For example, a collaborative effort with ExxonMobil has culminated in the Tapis EOR project, off-Terengganu. The Tapis project includes seven fields: Seligi, Guntong, Tapis, Semangkok, Irong Barat, Tebu and Palas. The project is expected to extend the fields' lives by 30 years and add another 25,000 barrels per day to current production. Two more EOR projects offshore Sarawak and Sabah are also underway as a result of an agreement between PETRONAS and Shell with investment reaching up to $12 billion over 30 years. The projects will employ the world's first offshore chemical injection process for resource recovery.

PETRONAS also offers risk service contracts (RSC) to attract new investment in small marginal fields through Enhanced Oil Recovery (EOR). According to the terms of RSC, PETRONAS owns the project and investors are the service providers that are entitled to revenues on oil produced throughout the entire life of the project. In such arrangements, PETRONAS and project contractors share the risk of the venture. Exploration in deep-water offshore areas of the Sarawak and Sabah Basin has resulted in new oil and natural gas discoveries (e.g., Kikeh, Kakap and Malikai fields). Although these deep-water offshore fields pose more technical challenges, they offer new opportunities to increase domestic production and to offset the current declines in production levels from ageing fields.

4.0.3 Pharmaceuticals Industry

The pharmaceuticals industry is an important component of and innovation driver for the healthcare system. Driven by increased healthcare needs, there is continuous growth in the demand for pharmaceuticals locally and globally. The total government expenditure on medicine is expected to continue at a 10% per annum growth rate (Nawi, 2013). Much of this is motivated by increasing consumer spending on over-the-counter (OTC) drugs and dietary supplements and herbal and traditional medicines.

According to the ETP Annual Report (2014) Review, 2014 recorded a 9% growth in income generated from pharmaceutical exports, surpassing the year's target of 5%. According to MATRADE (2016b), there are 74 licensed pharmaceutical manufacturers in Malaysia. Another 176 manufactures are licensed to produce traditional medicines. Malaysia has the advantage of a well-regulated pharmaceutical industry. Being a member of PIC/S since 2002, Malaysia has strong Good Manufacturing Practices (GMP) regulations, helping Malaysian pharmaceuticals ensure that they are compliant to international standards. Furthermore, Malaysia has an additional advantage of a credible Halal platform and is one of the first Muslim nations to manufacture Halal certified pharmaceuticals.

Although Malaysia is an attractive location for global pharmaceutical companies to set up regional offices, their operations are unfortunately limited to sales and marketing. Ground-breaking research is typically undertaken at the MNCs' respective headquarters in their home countries, or at research centres that are based in Singapore, Hong Kong and China, with only application-led R&D taking place in Malaysia.

The global pharmaceuticals industry is monopolised by a small number of pharmaceutical giants. The largest of players, such as Pfizer, AstraZeneca, GlaxoSmithKline, Novartis, Sanofi, Abbott and Roche, have majority control over the pharmaceuticals industry. These giant players have high capabilities in fundamental R&D and strong ability to manufacture and market their products on a global scale. Their control over the supply chain is evident and they continuously consolidate through mergers and takeovers. In Malaysia, they remain the incumbents in the originator drugs industry. At the moment, there are no local companies that can match these firms in terms of their financial backing and R&D capability. Consequently, local players focus on the production of generic drugs and nutraceuticals. There are few domestically-led advances in originator drugs as the local focus is on incremental R&D and extraction of active ingredients and improving efficacy of nutrients from natural sources (e.g., honey, longjack, mangosteen). The main export products for the pharmaceutical industry include antibiotics, hormones, alkaloids, reagents, glycosides, vitamins and vaccines. These goods are primarily exported to Singapore; other principal export markets include Indonesia, United States, Vietnam and Hong Kong.

One of the main challenges in the generic pharmaceutical industry is the small market value and low profit margins. In addition, the competition in generics is very strong and is price-based, rendering it a challenge for local firms to increase their profitability through value-added propositions. However, some players are starting to realise that product differentiation and niche markets are critical for business continuity. Local manufacturers, especially small enterprises, may find better opportunities in products that cater to specific submarkets, such as nutra-pharmaceuticals, herbal drugs, halal alternatives, novel dosage forms and drugs for tropical diseases. Tropical disease represents a largely overlooked category as MNCs continue to focus on treatments for global, mostly western, diseases. This presents a potential niche for domestic players to make breakthrough discoveries and innovative drugs.

To spur the discovery of originator drugs, the Malaysian Government invested almost $13 million to establish clinical research hubs around Malaysia (Gross, 2014). This initiative involves a network of 27 clinical research centres linked with public healthcare facilities. The network of over 50 hospitals, 100 clinics, and nearly 600 clinical investigators allows access to 18 million potential patients. The target is to have 1,000 clinical trials conducted in Malaysia by 2020.

The government has also been successful in attracting MNCs to set up manufacturing operations through partnerships between local and foreign companies. An example of this is the partnership between AFT Pharmaceuticals, a privately owned company with operations in Australia and New Zealand, and a local manufacturer to produce orphan drugs in Malaysia.

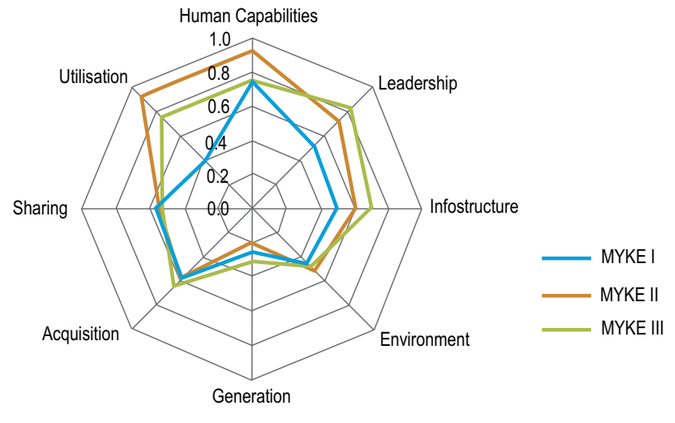
The efforts by the Government to attract foreign investment and manufacturing operations, and the development of clinical research network are all in the interest of nurturing the pharmaceutical industry to create a multiplier effect and help patients gain quick access to latest drugs. Ultimately, this will also help to improve the Malaysian healthcare system.

4.1 Knowledge Content

The chemicals, petroleum and pharmaceuticals industry shows complex development in the knowledge resource foundations over the period of 2003 to 2014. **Figure 4.1** shows year-on-year positive changes in firms' awareness of knowledge management and use of technology, but a decline in human capabilities and engagement with broader knowledge institutions. Assessment of performance in knowledge actions shows improvement in knowledge generation as a result of R&D activities and more patented work between 2007 and 2014. However, 2014 shows a decline in firms' ability to leverage on experiential and external knowledge, as well as a decline in knowledge sharing.

Figure 4.1: Knowledge Enablers and Knowledge Actions for MYKE I, II and III

Chemicals, Petroleum & Pharmaceuticals



4.2 Knowledge Enablers

4.2.1 Human Capabilities

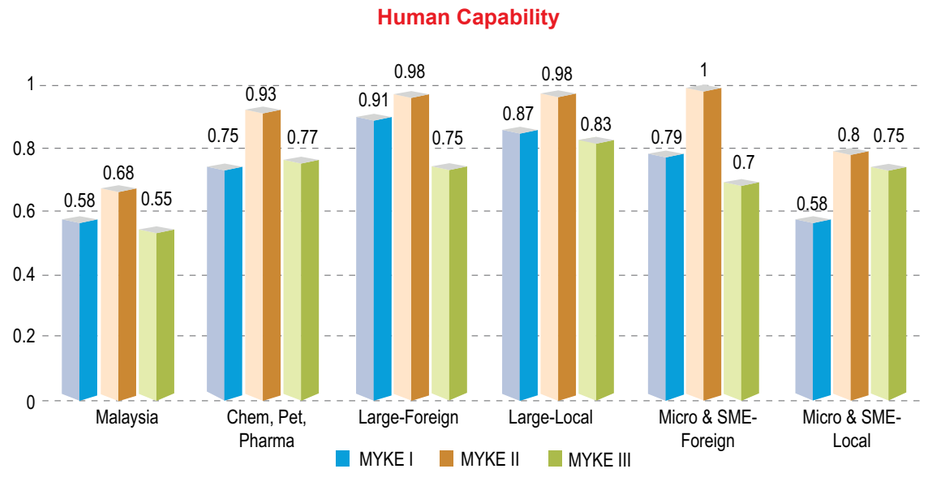
The industry for chemicals, petrochemicals and pharmaceuticals shows a level of human capability that is higher than the national aggregate. This is due to the knowledge-intensive nature of the industry. Firms operating in this industry require high technical and scientific knowledge and seek employees with more extensive qualifications who can engage in R&D. Thus, they place emphasis on employee training to remain informed on the latest scientific developments in the industry. Most micro and SME firms perform better than the national aggregate in terms of human capability. Nonetheless, consistent with the national pattern, the industry was unable to sustain the positive trend. Over the period of 2007 to 2014, human capability dropped from 0.93 to 0.77.

The drop in the industry's human capability could be a result of the growing need for more research-oriented skills. Although there is a sufficient number of basic degree holders in the industry, there is a shortage of highly trained employees capable of intensive and leading-edge research. At the same time, there is a change in employment culture among the younger jobseekers. In the past, people looked for life-time employment tied to heavy pensions, but the current generation tends to switch jobs frequently.

This discourages companies, especially SMEs, from investing in employee development and training.

All firm categories, even micro and SME firms, in this industry perform above the national aggregate level. The interesting positive development here is that local firms, large and small, do better than their foreign counterparts. This reflects positively on local companies' ability to attract local talent. Also, the gap between large and small firms is marginal, signifying the competitiveness of small firms in this industry.

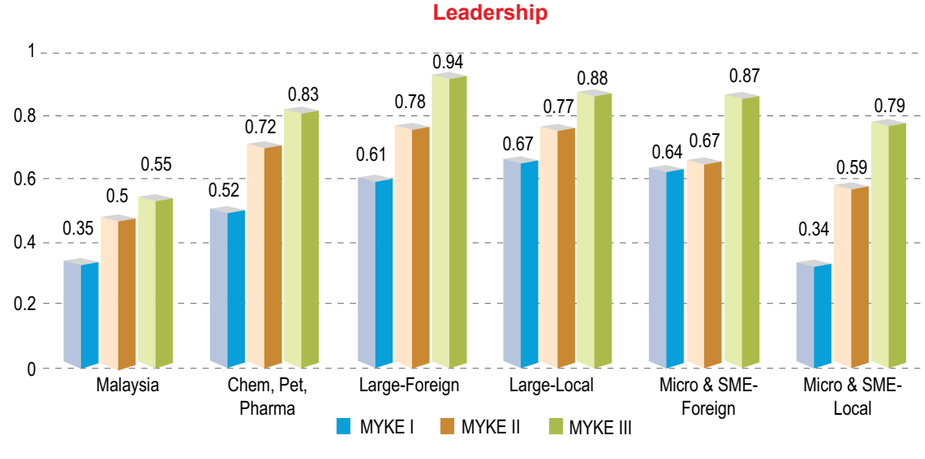
Figure 4.2: Human Capability of the Chemicals, Petroleum and Pharmaceuticals Industry



4.2.2 Knowledge Systems and Leadership

Malaysian companies in the chemicals, petroleum and pharmaceuticals industry show a steady positive trend with respect to developing strategies and processes for knowledge management. The industry is above the national aggregate in their approach to knowledge management. The improvement is consistent across all firm categories regardless of the firm's size or nationality of its ownership. This is expected because the ability to cultivate formal strategies, systems and processes to both capture and use knowledge is especially important in highly technical and knowledge-intensive industries. The most significant improvement was made by small local firms between 2003 and 2014, which managed to substantially close the performance gap with other firm categories over time. Currently, the gap between different firm size (large or small) and firm origin (local or foreign) is very small, reflecting a high awareness among all firms on the importance of capturing and documenting knowledge.

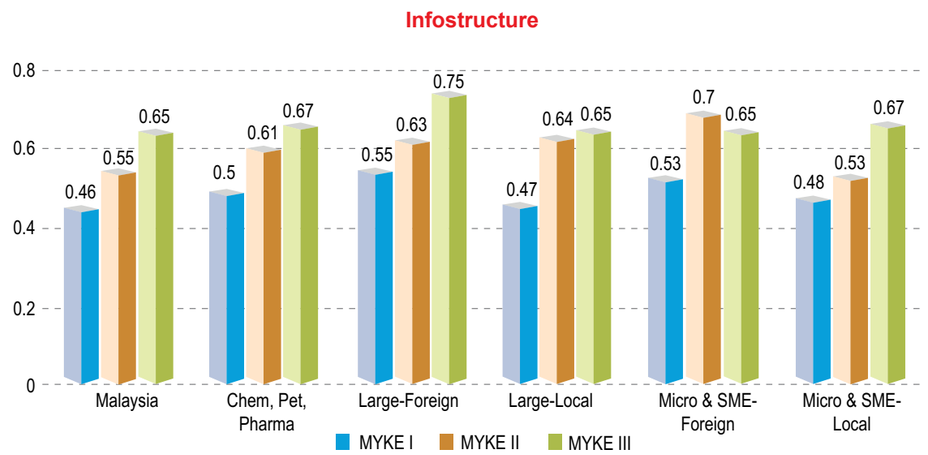
Figure 4.3: Knowledge Leadership in the Chemicals, Petroleum and Pharmaceuticals Industry



4.2.3 Technology and Infostructure

Figure 4.4 shows that the level of technology-based infostructure improved in the chemical, petroleum and pharmaceutical industry over the period of 2003 to 2014. Over the years, the industry maintained its performance slightly above the Malaysian aggregate level. Large foreign firms exhibited better performance in terms of computer availability per employee compared to other firms over the years. However, local firms also made significant improvements to their infostructure capability.

Figure 4.4: Technology and Infostructure of the Chemicals, Petroleum and Pharmaceuticals Industry



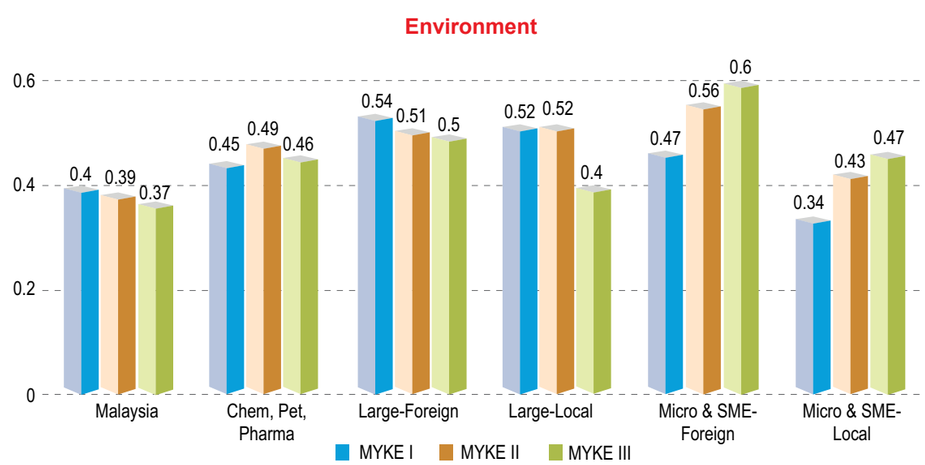
4.2.4 Knowledge Environment

The chemical, petroleum and pharmaceuticals industry showed improvement in the level of engagement with institutional knowledge at the aggregate level in 2003 to 2007. This was followed by a slight decline in 2014, which matches the incremental decline in engagement over time of Malaysian industry as a whole. In contrast to large firms, it was micro and SME firms in the industry, both local and foreign, which had stronger engagement with knowledge initiatives from government agencies, associations and universities. By 2014, foreign micro and SME firms exceeded all other firm categories in their level of engagement with knowledge support institutions. Similarly, local micro and SME firms in the industry performed better than their large local counterparts.

It is possible that micro and SME firms show more active engagement to compensate their weaker resource positions through collaborations with external institutes. Most government incentives and programs are geared towards helping SMEs to grow and develop, and this could be a reason for higher engagement from the small players. As for the lower engagement from the big players, this may be

ascribed to weakness in the Malaysian knowledge environment. It is possible that formal knowledge institutes in the form of universities and research centres are not able to play their role as knowledge partners to the extent that is desired by large industry players.

Figure 4.5: General Environment Awareness of the Chemicals, Petroleum and Pharmaceuticals Industry

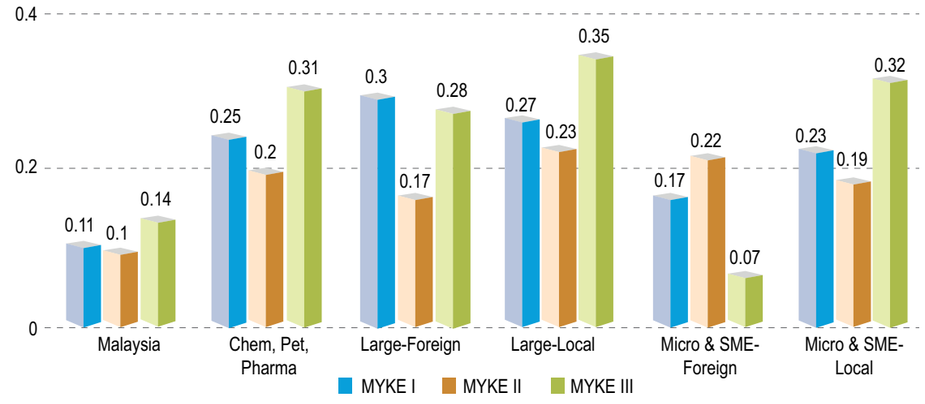


4.3 Knowledge Actions

4.3.1 Knowledge Generation

The chemicals, petroleum and pharmaceuticals industry aggregate dropped in 2007, but thereafter showed good recovery and by 2014 it registered a higher level of R&D engagement, and patent and copyright filings. Although the industry started at a low-base of knowledge generation, it still performs better than the Malaysian industry aggregate. An interesting development is the rapid improvement in the performance of local firms over the period 2007 to 2014, having exceeded foreign firms within that timeframe. This reflects a measure of success in government initiatives, financial support and development programs to push R&D activities in the industry. Large companies in the petrochemicals and pharmaceuticals industry work closely with suppliers and downstream players on R&D projects. Companies like PETRONAS, for instance, run development projects to help local players, especially small firms, to enhance their R&D capability. Meanwhile, the decline in foreign firm's performance is likely the result of these firms' tendency to centralise their R&D activities in their country of origin and only set up sales and marketing offices in Malaysia. Therefore, their knowledge generation is done outside Malaysia.

Figure 4.6: Knowledge Generation Activity in the Chemicals, Petroleum and Pharmaceuticals Industry

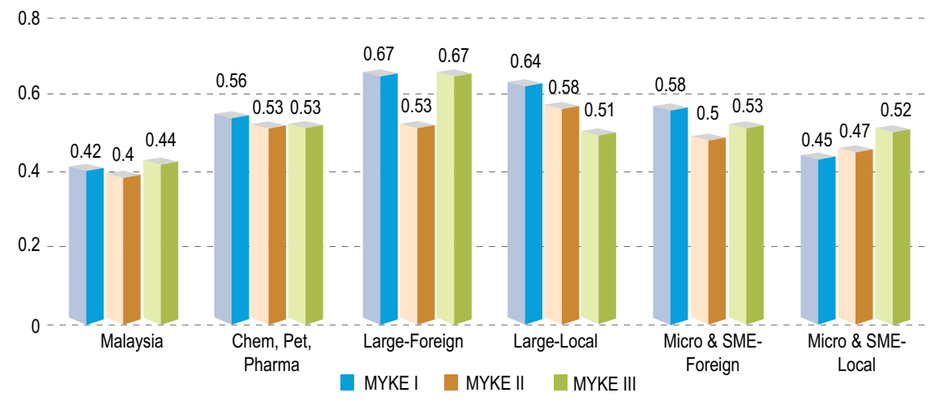


4.3.2 Knowledge Sharing

Knowledge sharing in the chemicals, petroleum and pharmaceutical industry is a little higher than the Malaysian aggregate. Knowledge sharing declined slightly after 2003 and plateaued into 2014. The pattern varied across the different firm categories. Large foreign firms, despite falling behind in 2007, bounced back up and returned to being the highest ranked in terms of knowledge sharing in 2014.

It is interesting to notice that small local players began to open up and share more with their industry; meanwhile, the big local players began to share less. It is possible that as competition becomes tougher and small players grow in market presence, the big players are becoming more protective of their market share and, therefore, become more cautious about disclosing the knowledge they possess. The sensitive nature of the industry and the need for intellectual property and protection also contributes to the decline in knowledge sharing by the big firms.

Figure 4.7: Knowledge Sharing Activity of the Chemicals, Petroleum and Pharmaceuticals Industry



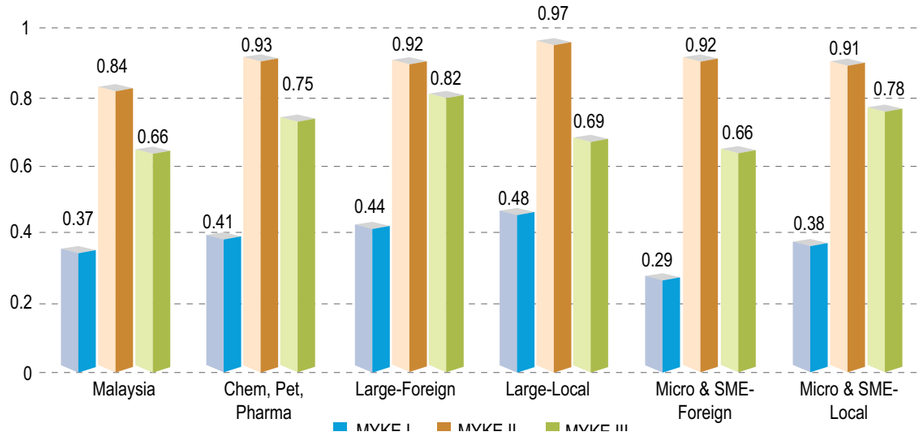
4.3.3 Knowledge Utilisation

Consistent with the trend of the Malaysian aggregate in terms of use of experiential and external knowledge, the chemicals, petroleum and pharmaceuticals industry experienced a slight drop in knowledge utilisation in 2014 after a significant development in the period from 2003 to 2007. Notwithstanding the slight drop, the industry's level of knowledge utilisation remained higher than the national aggregate across all time periods. All firms in the industry showed a similar trend of considerable improvement in 2007 before a decline in 2014. Knowledge utilisation almost doubled between 2003 and 2007, but the gap between different firm types grew over the period to 2014. Large foreign firms sustained strong knowledge utilisation compared to the other categories. Strikingly, small local firms performed better at knowledge utilisation than large local and small foreign firms.

Overall, the chemicals, petroleum and pharmaceuticals industry shows mixed results with improvement in some knowledge enablers and actions, but a decline in others. In general, the industry maintains higher performance than the national aggregate on all knowledge sources, which is to be expected of knowledge intensive-industries. Consistent with the Malaysian industry aggregate, this industry faced a decline in human capabilities, probably due to competition from other industries over talent. Also, as firms in this industry attempt to engage in more R&D, their needs for advanced skills and knowledge also increased, but development in human capital has not kept pace with industry needs. Positive achievements are seen in technology adoption and use of computers as well as in firms' adoption of formal processes and strategies to manage knowledge within the firm regardless of firm size. Knowledge generation improved in 2014 as well, but from a comparatively lower baseline. Here, local firms outperformed foreign ones in their engagement in R&D and patent/copyright-filing. However, it should be noted that foreign companies located in Malaysia mainly focus on sales and marketing to the region and conduct their R&D and patent-filing elsewhere.

Overall, it is heartening for small local players to be catching up with their larger peers, and even outperforming them in certain areas, such as engagement with the knowledge environment, knowledge sharing and utilisation. In general, the gap between small and large local firms is disappearing across knowledge resource foundations. This has alarmed the large local players and resulted in a decline in their knowledge sharing within the industry.

Figure 4.8: Knowledge Utilisation Activity of the Chemicals, Petroleum and Pharmaceuticals Industry

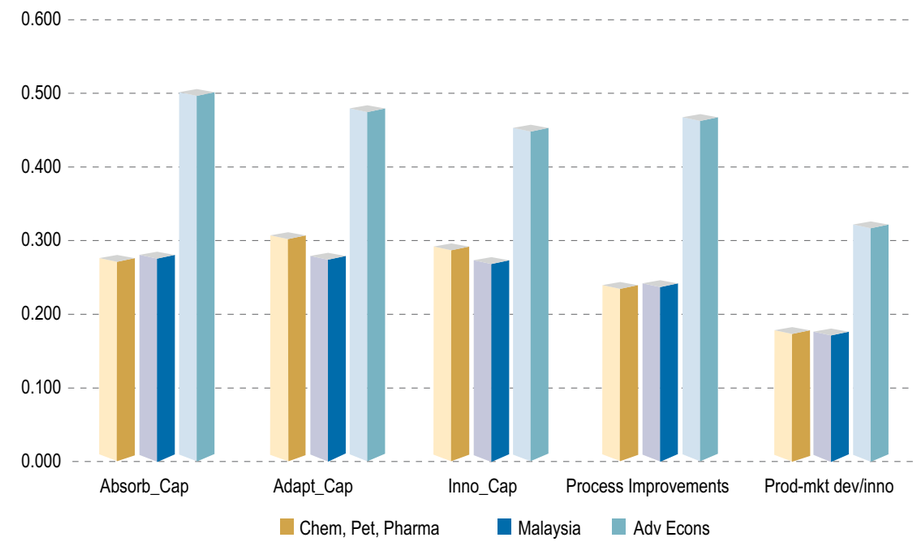


4.4 Dynamic Capabilities Profile for Chemicals, Petroleum and Pharmaceuticals Industry

The knowledge resource foundations of the chemicals, petroleum and pharmaceuticals industry show a mixed pattern of progress in some areas and stagnation and decline in others. This section discusses the dynamic capabilities of the industry. Dynamic capabilities reflect a firm's ability to change and adapt to changes and developments in its business environment. High dynamic capabilities indicate the ability to adapt to change and use it to create competitive strength. In contrast, low dynamic capabilities indicate weakness in recognising and adapting to changes in the industry and difficulty in creating competitive strength.

The chemicals, petroleum and pharmaceuticals' dynamic capability profile in Figure 4.9 indicates that the industry performs just a little below national aggregate in absorptive capabilities, and above national aggregate in adaptive and innovative capabilities.

Figure 4.9: Dynamic Capability Profile of the Chemicals, Petroleum and Pharmaceuticals Industry

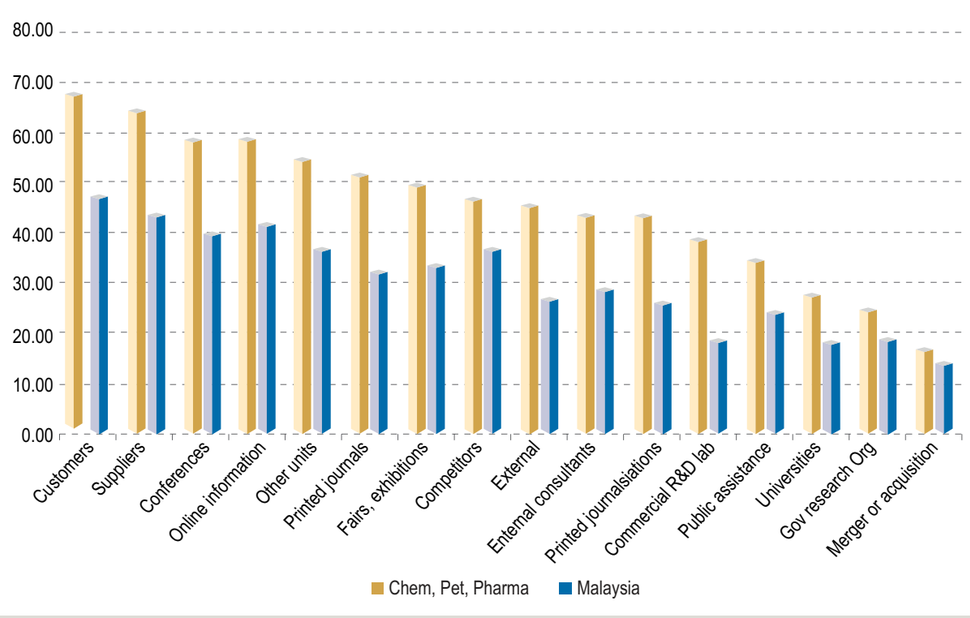


4.4.1 Absorptive Capability

Stronger absorptive capability is indicative of an industry where firms scan the market for customer insights, and systematically handle and store the knowledge collected from external sources. Such firms exhibit a higher tendency to acquire new technology and communicate knowledge and try to fully understand and use it. **Figure 4.9** shows firms in the chemicals, petroleum and pharmaceuticals perform slightly below the national aggregate. Given the R&D-intensive nature of the chemical, petroleum and pharmaceutical industry, a natural expectation would be for firms to show higher than national aggregate absorptive capability.

Figures 4.10 shows that the industry acquires much knowledge from customers, suppliers, conferences and online sources. This indicates strong linkages between the firms in the industry and their customers and suppliers. Conferences and online information are also important sources of knowledge and allow firms to access information about developments in the regional and international scene. Overall, firms in the chemicals, petroleum and pharmaceuticals industry are at a level that is much higher than the Malaysian aggregate in terms of tapping different sources of information, both public and private. However, when one considers this evidence in relation to the industry's score on absorptive capability, which is slightly lower than Malaysian aggregate, the evidence becomes telling. It would appear that although considerable investment is made in acquiring information from a wide range of resources the internal communication, effective storage and deep understanding of knowledge remains weak and hence absorptive capability is not as high as expected.

Figure 4.10: Sources of Knowledge in the Chemicals, Petroleum and Pharmaceuticals Industry



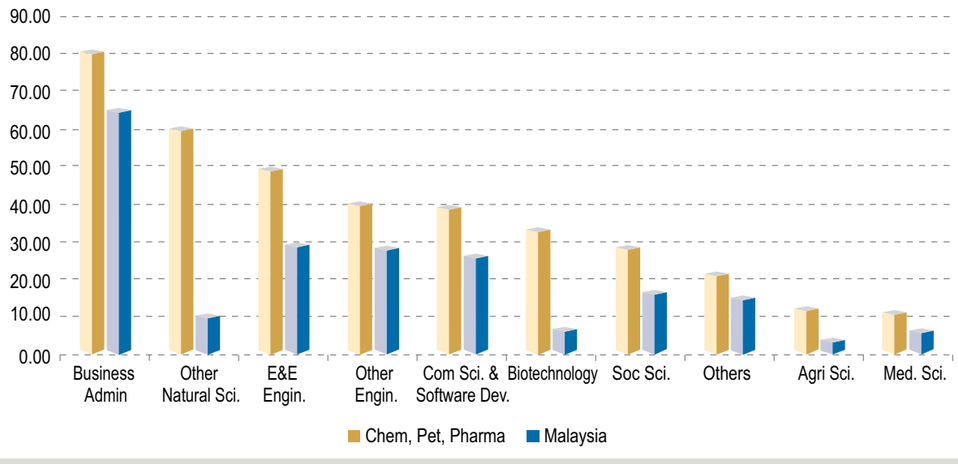
4.4.2 Adaptive Capability

Adaptive capability enables firms to make use of the knowledge they acquire from external sources. **Figure 4.9** shows that the chemicals, petroleum and pharmaceuticals industry has high levels of adaptive capabilities, and its performance is significantly better than the national aggregate. High adaptive capability indicates strength in firms' ability to continuously reconfigure its processes, resources and assets to allow best use and creation of knowledge. Firms in the chemicals, petroleum and pharmaceutical industry show a stronger commitment to invest resources in new projects and new improvements, and make the needed changes in their processes and structures.

Possessing adequate skills and expertise is fundamental in developing adaptive capability. **Figure 4.11** shows the skills profile in the chemicals, petroleum and pharmaceuticals industry. As the numbers indicate, the industry has good concentration and mix of human capability. The largest group in the industry is constituted of business and administration graduates. As expected, the industry also has a high composition of natural science, electrical and electronic engineering, general engineering, computer science and biotechnology graduates.

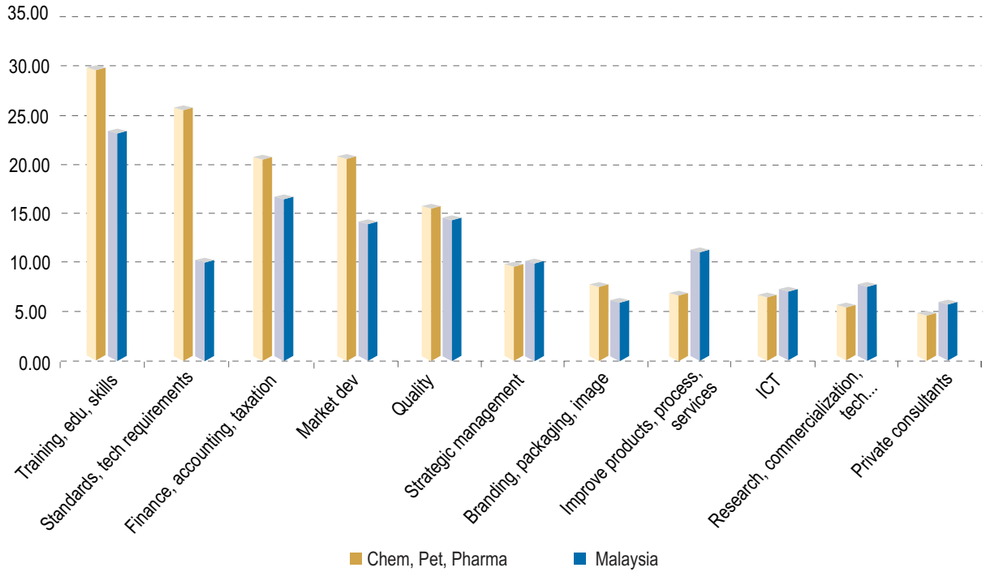
There is a lower number of employees from other disciplines, such as agriculture and medical sciences. Nonetheless, the number of employees in all skills categories is higher than the national aggregate level. The industry could do with a higher number of biotechnology and medical science employees as this will give a human capital boost to chemical and pharmaceutical firms. Employees with skills in R&D are particularly needed in this industry. Nonetheless, the figures give a positive indication of the overall level of human capital development in the industry and its potential if the human capability is properly leveraged.

Figure 4.11: Skills Profile of the Chemicals, Petroleum and Pharmaceuticals Industry



The institutional environment in Malaysia plays a role in capability building (**Figure 4.12**). Firms benefit from the various types of assistance provided by government agencies, industry association and universities. The most sought-after assistance is training, educational and skills enhancement. Firms also seek assistance to improve their understanding of quality standards, finance and accounting, and help in developing market strategies. Although the industry receives assistance in a number of areas, there is a modicum of help that the industry gets in areas such as strategic management, branding, product improvement and research development and commercialisation.

Figure 4.12: Role of Institutional Environment in Skill Building of the Chemicals, Petroleum and Pharmaceuticals Industry

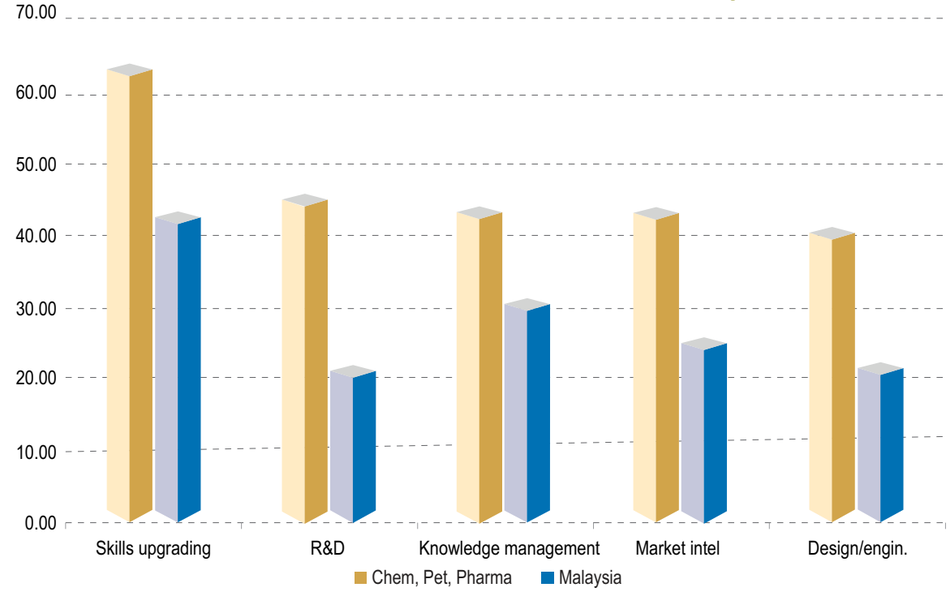


4.4.3 Innovative Capability

Firms in the chemicals, petroleum and pharmaceuticals industry engage in a much higher level of innovative capability building activities compared to the Malaysian aggregate (Figure 4.13). Firms demonstrate a much higher level of investment in R&D and design and engineering improvements, and in market intelligence. In addition, they also show focus on improving knowledge management and skill enhancement to boost their adaptive capability.

Innovative capabilities are represented by the ability to leverage on existing market knowledge and technology, and the integration of resources and knowledge in order to quickly seize emerging opportunities and create advantageous position. Firms in the chemicals, petroleum and pharmaceutical industry demonstrate innovative capabilities higher than national aggregate level. This is a good indication of firms' ability to respond to market opportunities.

Figure 4.13: Knowledge Intensive Activities in the Chemicals, Petroleum and Pharmaceuticals Industry

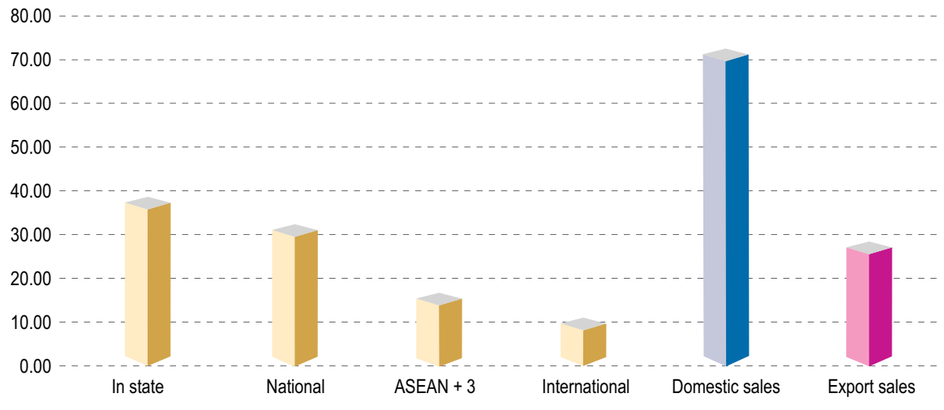


4.5 Outcomes of Dynamic Capability in the Chemicals, Petroleum and Pharmaceutical Industry

The chemicals, petroleum and pharmaceuticals industry is mainly orientated domestically, with 71.61% of revenues originating from the home market (**Figure 4.14**). Firms in the industry have good sales activities across the nation, indicating good balance between in-state and national sales. Within the state sales revenue make up to 38.99% whilst national sales make up 32.62% of revenues.

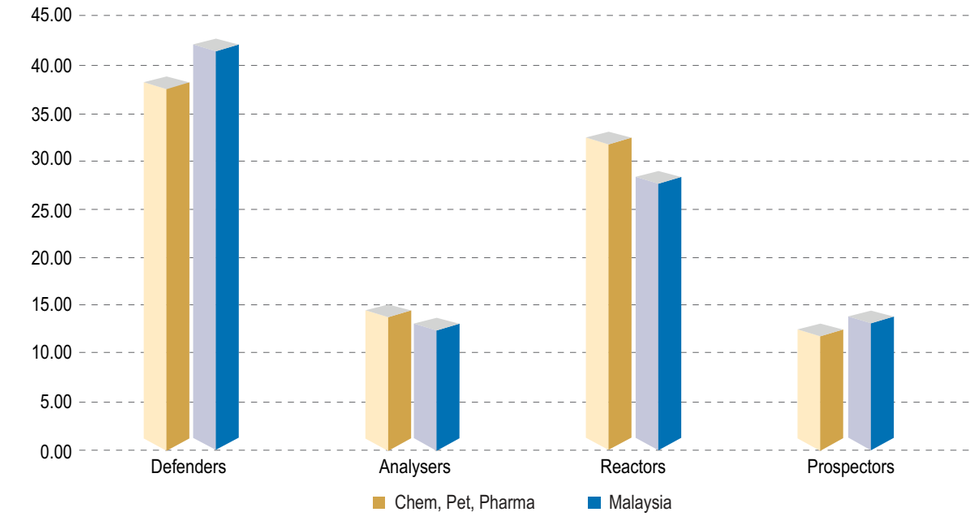
Chemicals, petroleum and pharmaceuticals industry shows promising signs, although its performance at the moment evidences an average level of dynamic capabilities. Even though firms in this industry have stronger adaptive and innovative capabilities, they are not able to translate this into enterprise-wide process improvements or novel market-leading products. This suggests reliance on buying technology and knowledge, and simply adapting it into already existing products and services.

Figure 4.14: Market Presence of the Chemicals, Petroleum and Pharmaceuticals Industry



Note: The results are based on survey data.

Figure 4.15: Strategic Profile of firms in the Chemicals, Petroleum and Pharmaceuticals Industry



Further analysis on the strategic profile of firms in the chemicals petroleum and pharmaceuticals industry in **Figure 4.15** reveals a strong presence of companies that are Defenders (39%) and Reactors (33%). Defender companies show low preference for developing new products, but higher proclivity toward trying to improve upon existing offering in the marketplace. Reactor firms respond to change when their very existence is threatened as opposed to adapting to changes in technology and market opportunities. These two types of companies constitute 72% of the firms in the industry. The chemicals, petroleum and pharmaceuticals industry has fewer defenders than national aggregate but more reactors. The third group, Analysers, constitute 15% the industry and the smallest group is of Prospector firms at 13%.

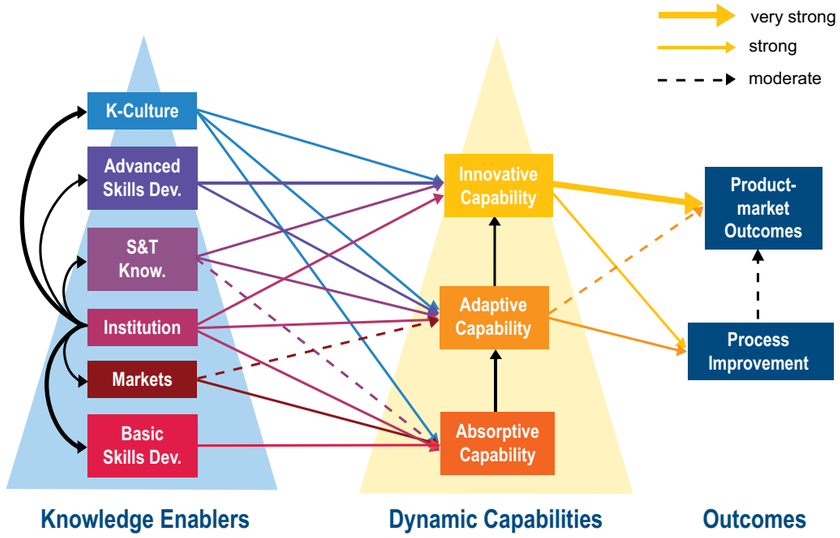
Overall, the chemicals, petroleum and pharmaceuticals industry has a majority of Defender firms that focus on operational optimisation rather than innovation. The industry also has many Reactor firms, which are characteristically laggards. This is worrying for a research-intensive industry, exacerbated by its low percentage of Prospector firms (lower than the Malaysian aggregate).

4.6 Relationships between Key Blueprints of the Chemicals, Petroleum, and Pharmaceuticals Knowledge Ecosystem.

This section explains the impact of knowledge enablers on dynamic capabilities, and the economic outcomes for the chemicals, petroleum, and pharmaceuticals industry. To provide a meaningful comparison, the knowledge ecosystem for the chemicals, petroleum, and pharmaceuticals industry in Malaysia is benchmarked with that of advanced sector countries (Canada, Germany, Japan, Russia, United Kingdom, and United States). Premised on content analysis and data obtained from DOS, the chemicals, petroleum, and pharmaceuticals industry in Malaysia is categorised as a Pace-setter. The chemicals, petroleum, and pharmaceuticals industry is among those that exhibit the highest levels of knowledge content and innovations.

Figure 4.16 shows the knowledge ecosystem for the chemicals, petroleum, and pharmaceuticals industry in advanced sector countries. From this figure, the knowledge ecosystem of the chemicals, petroleum, and pharmaceuticals firms in advanced countries supports all three components of the dynamic capability in creating significant product and process

Figure 4.16 Knowledge Ecosystem of the Chemicals, Petroleum and Pharmaceuticals Knowledge Ecosystem of Advanced Country



Note: Very strong impacts are represented by the bolded line, strong impacts are represented by normal lines and moderate impacts are represented by dotted lines.

innovations. These firms have strong absorption capability that feeds into adaptive capability through concerted efforts. The strong absorptive and adaptive capabilities in advanced sector countries combine to create a strong stimulus in innovative capability outcomes, leading to a significant variety of process improvements and development of globally competitive products.

The knowledge ecosystem for the chemicals, petroleum and pharmaceuticals industry in Malaysia is presented in **Figure 4.17** (as per data obtained from DOS). From the findings illustrated in this figure, firms in the Malaysian chemicals, petroleum, and pharmaceuticals industry knowledge ecosystem is relatively weaker than that of advanced sector countries. There are a number of differences between the knowledge ecosystem in advanced sector countries and in Malaysia. Examining the chemicals, petroleum, and pharmaceuticals industry in advanced sector countries, we find that S&T knowledge has a positive and significant impact on innovative capability. In contrast, in Malaysia, there appears to be a negative impact on innovative capability, indicating an opportunity cost. This can appear when investments are funnelled to develop S&T technical skills without associated investment into R&D, expertise, research personnel or S&T infrastructure to support innovative capability development in the industry.

Figure 4.17 shows that the knowledge ecosystem in the Malaysian chemicals, petroleum, and pharmaceuticals industry supports all three dynamic capability components, but nonetheless, these capabilities primarily create process improvement. There is some flow from adaptive capability to product market outcomes, and much of this is directed to the development of generic products based on existing patents or niche products, such as solution-based cleaning chemicals, industrial lubricants and halal pharmaceuticals.

Figure 4.17 Knowledge Ecosystem of the Chemicals, Petroleum, and Pharmaceuticals Industry in Malaysia

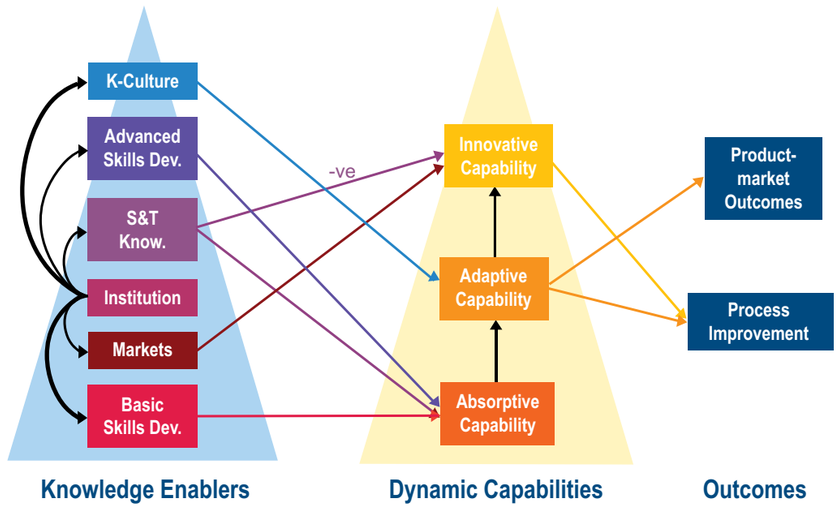


Table 4.1 provides a summary of the strengths of the chemicals, petroleum, and pharmaceuticals knowledge ecosystem in advanced sector countries and in Malaysia. Comparative analysis shown in the table suggests that the knowledge ecosystem for the chemicals, petroleum, and pharmaceuticals industry in Malaysia is relatively weaker than that of advanced sector countries.

Table 4.1: Knowledge Enablers and Dynamic Capabilities for the Chemicals, Petroleum and Pharmaceuticals Industry

Advanced Countries	Malaysia
Basic skills produce a **positive and strong impact** on absorptive capability. Basic skills in advanced sector countries are widely available are possess considerable flexibility and diversity to be up-skilled and trained into highly capable component of the workforce. These positive qualities can be attributed primarily to initiatives that develop and sharpen basic skills. A range of agencies come together to achieve this, such as government agencies, regulatory authorities, industry associations, and institutions of learning.	Basic skills produce a **positive and strong impact** on absorptive capability. Continuous upgrading of basic skills relevant to the chemicals, petroleum and pharmaceuticals industry in Malaysia takes place through similar types of institutions as in the advanced sector countries – examples of Malaysian institutions include Ministry of Natural Resources and Environment, Ministry of International Trade and Industry, Universiti Sains Malaysia, and Universiti Teknologi MARA. Unfortunately, the same effect is not achieved due to a lack of coherence in the execution of programmes.

Table 4.1: Knowledge Enablers and Dynamic Capabilities for the Chemicals, Petroleum and Pharmaceuticals Industry (cont'd)

Advanced Countries	Malaysia
Market intelligence produces a **positive and strong impact** on absorptive capability and a positive and moderate impact on adaptive capability.	Market intelligence produces a **positive and strong impact** on innovative capability.
Suppliers, customers, competitors, external consultants and commercial R&D centres in advanced sector countries contribute to a strong absorption of new knowledge in the chemicals, petroleum and pharmaceuticals industry, most notably in the areas of technology. There is also a strong focus on developing new cost-efficient products and services.	The chemicals, petroleum, and pharmaceuticals industry is dependent upon suppliers, customers, competitors, external consultants and commercial R&D centres in engaging with the innovations process. Most new innovations are incremental in nature or cost-efficient versions built on the proprietary knowledge of others.
Institutions are **strong enablers** of the knowledge ecosystem and produce **direct strong and positive impact** on all components of dynamic capability.	Institutions are **strong enablers** for all knowledge enablers, but they **do not have any direct impact** on any of the components of dynamic capability.
The institutions, such as regulatory authorities, trade associations, government research institutions, and universities, play key roles in creating a vibrant knowledge ecosystem that drives dynamic capability building. They are involved in a variety of efforts to advance the level of skills, talent, and R&D base of the industry. There is a strong unified understanding of what needs to take place and all players come together in a strong collaborative effort and common vision for strengthening the industry.	Myriad institutions, such as government agencies, regulatory bodies and educational institutions, come together in regulating the industry. However, attempts to create enabling environments (e.g. sufficient talent and manpower), though commendable, fail to deliver the same level of effects as those found in advanced sector countries. One of the key weaknesses in this respect arises from the different agencies working in isolation and functional tubes rather than hand in hand. Consequently, institutions do not directly influence the dynamic capability components of firms in the chemicals, petroleum and pharmaceuticals industry.
S&T knowledge has a **positive and moderate impact** on absorptive capability, and a **positive and strong impact** on adaptive and innovative capabilities.	S&T knowledge has a **positive and strong impact** on absorptive capability, but a **negative and strong impact** on innovative capability.
New innovations and scientific development are of fundamental importance in the chemicals, petroleum, and pharmaceuticals industry. A strong foundation of basic and applied research in the Science, Technology, Engineering and Medical (STEM) fields is of critical importance in ensuring	Most chemical, petroleum, and pharmaceutical players in the industry remain users of new technology and innovations. S&T knowledge is dedicated to improving the absorptive capacity. R&D in the chemicals, petroleum, and pharmaceuticals industry is at an embryonic stage, and require

Table 4.1: Knowledge Enablers and Dynamic Capabilities for the Chemicals, Petroleum and Pharmaceuticals Industry (cont'd)

Advanced Countries	Malaysia
that the sector has the best talent and specialist skills for breakthrough advances. This is further strengthened by significant investments to ensure theoretical knowledge developed in research labs is effectively commercialised in the form of world leading products and services.	considerable strengthening before they are able to be at the forefront of innovation, except in niche areas where specific knowledge or abundance of resources in the form of flora and fauna or geology provides low level firms with a competitive and comparative advantage.
Advanced skills produce **a positive and strong impact** on both innovative and adaptive capabilities.	Advanced skills produce **a positive and significant impact** on absorptive capability.
Significant resources are allocated to strengthen the quantity and quality of workers with higher degrees and specialist knowledge relevant for the chemicals, petroleum, and pharmaceuticals industry. The existence of a strong 'quadruple-helix' helps in the effort, as it is key in creating the bridge that translates fundamental research into successful products through connective links for intrapreneurship and entrepreneurship.	An upward trend is observed in the level of quantum and quality of knowledge among workers in the chemicals, petroleum, and pharmaceuticals industry. However, there is a lack of integration of knowledge. Despite numerous programmes, Malaysia's 'quadruple-helix' remains weak, and there is a strong disruption in the integrated flow of advanced skills to adaptive and innovative capabilities within the Malaysian chemicals, petroleum, and pharmaceuticals industry. Thus, most workers in the industry are simply users of new technology and innovations; they are not producers of cutting-edge innovations.
Knowledge culture has a **positive and strong impact** on dynamic capability in the form of absorptive, adaptability, and innovative capabilities.	Knowledge culture has a **positive and strong impact** on adaptive capability.
The organisational structure and culture in chemical, petroleum, and pharmaceutical firms in advanced sector countries tend to be flat with a focus on outcome-based key performance indicators. The approach to innovation is based around an outcome driven approach, in which considerable space is provided for creative effort whilst at the same time having a strong process approach to facilitate systematic, efficient development and commercialisation. Diversity of perspective is valued and multidisciplinary perspectives are used to feed into the different stages of R&D and new product development process. Members at all levels of the firm continuously update themselves	Many chemical, petroleum, and pharmaceutical firms in Malaysia have an organisation culture that is hierarchical, in which R&D activities and initiatives are primarily undertaken by a few people or by a specific and dedicated department. These firms are unlikely to invest resources for R&D activities. Instead, they tend to rely on new knowledge, innovation and technology from advanced sector countries. The local institutional and regulatory environment also makes it difficult for firms to take long term risks to penetrate international markets with novel products and services.

Table 4.1: Knowledge Enablers and Dynamic Capabilities for the Chemicals, Petroleum and Pharmaceuticals Industry (cont'd)

Advanced Countries	Malaysia
on current and future trends via myriad approaches (e.g., brain storming, fore-sighting, and visioning). Constant mentorship and nurturing of talent in the different employment levels, mapping out of clear career paths for all employees with good support for professional development, and opportunities to develop and practice creative and innovative skills at work are present among firms in the chemicals, petroleum, and pharmaceuticals industry in advanced sector countries. Additionally, these initiatives help to attract the best talent from abroad in an intensively competitive talent environment.	
The continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** Having a strong R&D and a competent workforce with basic, technical, and R&D experience helps firms in the chemicals, petroleum, and pharmaceuticals industry to stay resilient in absorbing new knowledge. Having a strong foundation helps these firms to internally create an adaptive response that helps in transposing innovative capability into a stream of new products and services. A stable experienced workforce that is constantly updating and renewing its knowledge base as well as fresh talent from leading universities and research institutes, coupled with firms that are innovation orientated enough to invest for the long term underpin the success of the industry.	The continuum from absorptive capability to adaptive capability to innovative capability **is present.** Having a skilled workforce provides the capacity to adopt new knowledge generated from more advanced sector countries in the chemicals, petroleum and pharmaceuticals industry in Malaysia. Some level of refining and modifying of foreign knowledge and innovation is carried out to meet local and global demand for chemicals, petroleum and pharmaceuticals. However, the more demanding task of fundamental research and its translation into new-to-the-world products is not seriously considered within most local firms.

Table 4.2 provides a comparison on the flows from dynamic capabilities to economic outcomes in the chemicals, petroleum, and pharmaceuticals industry in advanced sector countries and in Malaysia. The impact of dynamic capabilities on economic outcomes for the chemicals, petroleum, and pharmaceuticals industry in advanced sector countries and in Malaysia varies considerably. In advanced sector countries, the adaptive capability of firms in the chemicals, petroleum, and pharmaceuticals industry has a positive and strong impact on process improvements and a positive and moderate impact on product market outcomes; and innovative capability of firms has a positive and strong influence on process improvement and a very strong to product market outcomes.

In Malaysia, the adaptive capability of firms in the chemicals, petroleum, and pharmaceuticals industry has a strong and positive impact on both process improvement and product market development. However, the innovative capability of firms only contributes to process improvements. These empirical findings suggest that firms in the Malaysian chemicals, petroleum and pharmaceuticals industry are active in adopting new and improved processes, and in making changes to organisational methods and marketing in line with changes that are taking place in the marketplace, even though they are not strong product innovators.

Table 4.2: Dynamic Capabilities and Economic Outcomes for the Chemicals, Petroleum and Pharmaceuticals Industry

Advanced Countries	Malaysia
Adaptive capability produces a **positive and strong impact** on process improvement and a **positive and moderate impact** on product market development. Chemical, petroleum and pharmaceutical firms are internally well structured and organised to enable them to continuously improve existing products and services, create new applications whilst deliver them to the marketplace in a highly cost efficient manner.	Adaptive capability produces a **positive and strong impact** on process improvement and a **positive and strong impact** on product market development. Much of the adaptive capability of firms in the chemicals, petroleum and pharmaceuticals industry is based on advanced sector countries' industry formats. Nonetheless, the Malaysian chemicals, petroleum and pharmaceuticals industry is able to make inroads into niche products and services that meet local demands.
Innovative capability produces a **positive and strong** impact on process improvement and a positive and very strong impact on product market outcomes. The emergence of new chemical, petroleum and pharmaceutical instruments, applications, products and services that meet both local and global market demands is the result of a strong innovative capability powered by sound S&T base, high R&D investment and strong quadruple-helix among all stakeholders.	Innovative capability produces a **strong impact** on process improvement only. Innovative does not impact product market outcomes. Many firms in chemicals, petroleum, and pharmaceuticals industry adopt new technology, systems, processes and management tools from advanced sector countries to improve cost-efficiency and service delivery targeted to local market needs.

Table 4.2: Dynamic Capabilities and Economic Outcomes for the Chemicals, Petroleum and Pharmaceuticals Industry (cont'd)

Advanced Countries	Malaysia
Process improvement produces a **positive and moderate impact** on product market outcomes. Process improvements in the chemicals, petroleum and pharmaceuticals industry are powered by a sound S&T base and effective efforts at the organisational level to improve the R&D to commercialisation pipeline in order to ensure the portfolio of long term investments is able to make sufficient level of returns. Process improvements feature as an important and critical part of the success formula.	Process improvement **does not impact** product-market outcomes. The potential for creating new market outcomes and intellectual property for the Malaysian chemicals, petroleum and pharmaceuticals industry is limited as most of the process improvements are based on the use of foreign technology, knowledge and intellectual property.

4.7 Summary: Key Trends, Challenges, Way Forward and Best Practices

4.7.1 Industry Trends

The chemicals, petroleum and pharmaceuticals industry has a number of positive developments taking place. The industry has gradually built stronger knowledge resource foundations over the years.
Although the industry shows progress in building knowledge resource foundations, robust dynamic capabilities have yet to be conceived. Firms in the chemicals, petroleum and pharmaceuticals industry show weakness in absorptive capability although their adaptive and innovative capabilities are a little above the national aggregate. Unfortunately, there is poor translation of these capabilities into innovation outcomes, with the industry being largely dominated by Defender and Reactor type firms that are disinclined to take investment risks required by new-to-world and new-to-market innovations.

There is no doubt that the chemicals, petroleum and pharmaceuticals industry has significant potential if its resources are leveraged through appropriate strategies.

4.7.2 Challenges

The chemicals, petroleum and pharmaceuticals industries are important contributors to the Malaysia economy. While the industries are more knowledge intensive compared to other industries, these industries face several challenges nevertheless. These challenges are discussed below.

Institutions:

- Attempts by regulators and industry agencies to create enabling environments (e.g. sufficient talent and manpower) have been numerous. However, these initiatives have failed to jumpstart Malaysia's transformation toward becoming an advanced global player in the chemicals and pharmaceuticals industries.

- This is because agencies tend to work in isolation, addressing market gaps in a fragmented, silo manner that dampens the direct influence of dynamic capability components of firms

- Foreign consumer groups, notably those in Europe are beginning to oppose palm oil -based oleochemicals on the grounds of sustainability. This will significantly impact the attractiveness of related commodities originating from Malaysia.

- Most firms in the pharmaceutical industry fail to successfully and viably commercialise as a consequence of firm resource weaknesses as well as institutional impediments and lack of support to penetrate international markets.

- In the pharmaceutical industry, there are also problems regarding policy implementation. Industry leaders note that many policies are instituted without the existence of adequate infrastructure and support facilities leading to policy implementations lacking monitoring.

Basic Skills Development:

- Lack of coherence in the execution of training and acceleration programmes by local government ministries and universities limit the progression of available talent for current market needs.

- Shortage in trainers and lack of appropriate, relevant training courses locally leads to high costs in human capital development.

- The price threshold for capable workers prohibits smaller firms from scaling up.

- Heterogeneity in the industry demands diverse skillsets; meeting current and potential demands for talent poses are greater challenge for chemical and pharmaceutical firms compared to most other verticals.

S&T Knowledge:

- Only a few niche areas are not highly technology and R&D intensive; however, the industry possesses a largely dormant R&D ecosystem, and will require considerable strengthening before it is able to create market-leading innovations.

- In the petroleum industry, only 8% of Malaysian companies actually own proprietary technological IP.

- In pharmaceutical manufacturing, underdeveloped upstream markets disrupt production inputs, and firms are additionally inhibited by the lack of suitable machinery and equipment to create seamless production chains.

Advanced Skills Development:

- Institutions of higher learning focus on training graduates to go into general practice, such as clinical practice, rather than create research-oriented talent.

- Firms in the pharmaceutical industry have yet to develop the capability to sustainably generate innovation on par with counterparts in more mature countries.

- There is a lack of knowledge collaboration and technology transfer among firms in the industry.

- Despite numerous programmes, Malaysia's 'quadruple-helix' remains weak, and there is a strong disrupt in the integrated flow of advanced skills to adaptive and innovative capabilities within the industries. Most workers in the industries are simply users of new technology and innovations. They are not producers of cutting-edge innovations.

Market Intelligence:

- Most firms, especially SMEs are not aware of leading-edge R&D and trends in the industry. Many do not invest appropriate resources to acquire valuable market intelligence to enhance the innovative capacity.

- Most new innovations by local firms are incremental in nature, often taking the form of low-cost upgrades built upon existing IP.

- The petroleum industry has been subject to volatile conditions that have adversely affected the commodity's price due to factors such as overproduction, cooling demand and intense price competition from OPEC nations.

- The situation is worsened by the declining production capacity of many Malaysian oil fields and the difficulty of prospecting new wells.

Knowledge Culture:

- Many firms in the industries have an organisation culture that is hierarchical in which R&D activities and initiatives are primarily undertaken by only a few people or by a specific department.

- Most local firms are highly dependent on foreign partners for new technology and innovations. These foreign players have long-term track record for advanced technology development, better R&D facilities and resources; hence local firms are higher primarily users of the technology than creators of 'home-grown' innovations. Due to high cost of R&D and low success rate of many of the R&D endeavours are uncertain; most of the local firms are 'risk-averse' in investing in R&D and expensive facilities.

- The local institutional and regulatory environment also makes it difficult for firms to take long term risks to penetrate international markets with novel products and services.

- The patenting processes are expensive and lengthy, especially if firms plan to register their intellectual property in foreign countries. Many of the smaller firms find the patenting process complex and time consuming. There is a tendency for local firms to sell their intellectual property to foreign firms that have better resources and global reach.

4.7.3 Way Forward

The chemicals, petroleum and pharmaceuticals industry is a key driver to a number of industries in Malaysia in their effort to move up the knowledge ladder. High capital outlays, combined with complex value chains of materials, expertise and logistics create substantial economic spill-over impacts across various principal sectors in the country. A number of steps and actions are required if the industries are to play an effective and increasing role in enabling high value-add growth of the economy.

Recommendation 4.1: Strengthen Basic and Applied Capability of Firms and Institutions in Line with Emerging Research Frontier Trends of Industries

- Incentivise universities and research institutes to develop specific areas of expertise, relevant to the needs of the industry.

- Create collaborative bridges between universities and industry through improved understanding of each other's expectations and needs through relationship building activities.

- Create mandatory mentorship and internship programmes to ensure practical exposure of undergraduates to industry practices.

- Incentivise R&D through subsidies and research-based KPIs to bolster the creation of local IP.

- Strengthen and expand demand driven centres of excellence in key areas of necessity; and ensure that they are an integral part of the global innovation of value chain, benefiting from knowledge flows and frontier technology development that are undertaken in other leading global centres of excellence.

- Build and sustain Higher Institution Centres of Excellence (HICOE) into global leadership positions through high-end research and close links with industry.

Recommendation 4.2: Create Real Knowledge Transfer Partnerships

- Proprietary knowledge necessitates an environment of integrity, with strong IP protection and sound IP infringements mechanisms.

- Facilitate win-win partnerships between universities, research institutes, local firms, MNCs with high level of expertise in key priority areas that will raise the innovative capacity and wealth creation opportunities for the industry.

- Strong implementation of Global Incentives for Trading (GIFT) to promote Malaysia as a regional hub for R&D and innovation in key areas; and enhance the opportunities to attract leading anchor firms and joint venture partnership that will transfer technology and knowledge to local firms.

- Create real knowledge transfers by encouraging incentives by bodies such as MIDA that draw knowledge transfer clauses into FDI agreements. Ensure that the partnership is audited for knowledge transfer on a regular basis.

- Key agencies for registering patents should work closely with universities, government research institutes and local firms to streamline the patenting process to ensure that it is cost-effective and not a protracted process. Agencies in partnership with trade associations should undertake regular capability development programs to educate researchers and firms on effectively protecting and getting better value from the intellectual property they generate.

Recommendation 4.3: Exploit Existing Technologies and Investments Effectively to Extend Knowledge Creation

- Identify and revitalise idle R&D projects and facilities within companies; complement independent restoration initiatives with standardised evaluation and benchmarking best practices through industry agencies.

- Appointment of innovation task force to fully evaluate the potential of past technology investments, and administer incremental knowledge improvements and skills extension within the organisation.

Recommendation 4.4: Encourage and Facilitate Market Expansion for Large Players and Developing Niche Strategies for Small Players

- Local firms must be able to differentiate their products and services in some unique way as the three industries are dominated by foreign companies which have significant resources, experience and economies of scale.

- Local companies need to create stronger, more competitive supplier ecosystems by systematically enforcing their brand presence.

- Cross-cultural training and improving the language proficiency of staff for expansion into new international markets is necessary.

Recommendation 4.5: Build Human Talent for Research Intensive Industries

- Closer collaboration of Talent Corp and National Human Capital Development Council (NHDC) is needed to evaluate the type of skills demanded by the local industry and put in place the correct inducement strategies to retain the best talent in Malaysia.

- Improve understanding and awareness that human talent will be a key feature in regional competitiveness.

- Improve competencies of individuals through student internships, graduate employability programmes, and industry driven research to ensure adequately skilled workers in the three industries.

Recommendation 4.6: Strengthen Institutional Integration to Enhance Innovative Capacity

- Greater coordination and integration of the master plans for the three industries (chemical, petroleum and pharmaceutical) with clear key focus areas of development that are strategic to the local industries. Clear implementation plans, milestones, key performance indicators are required in institutions responsible for meeting the KPIs and timelines.

- Fore-sighting and sign-posting of future downstream industries for all industries should be undertaken and key plans and support systems should be put in place to nurture the development of these new sources of growth for the economy.

- Identify and invest in niche areas that Malaysia can lead at the regional and global level, such as Halal-certified Pharmaceuticals.

- There needs to be greater interaction between the Pharmaceutical Master Plan, National Medicine Plan, the National Healthcare Plan and the National Tourism Plan – greater synergy will help foster stronger multiplier effect for all four industries.

- More strategic planning, support and championing among all institutions (government agencies, industry associations and universities/GRIs) to acculturate local firms to see the value of investing in long term scientific projects, research infrastructure, networking and building sustainable local and international partnerships to raise the innovative capacity of local institutions in all three industries.

- The use of Industry4.0 should be intensified in all three industries to improve greater efficiency, productivity, interaction and innovation.

- Development of a "one-stop station" in which the different agencies and processes are wholly integrated. This will make considerable improvement in reducing red-tape in obtaining expertise, funding, information and support for patenting and other resources for translating IPs into new industries and wealth creation opportunities.

- Greater support in the form of business development and branding should be given for local firms to strongly position themselves against competitors in the region and internationally.

4.7.4 Best Practices

The three industries have been undergoing rapid changes due technological breakthroughs; increasing demand for better health care and growing health pandemics; and falling petroleum prices. These factors are increasing competition for resources globally and likely to force firms to move up the knowledge and innovation value chain to get better returns on their investments. The challenge for local firms in these industries is to adhere to the global best practices to maintain their competitiveness both in domestic and global markets. Examples of global best practices are discussed below.

Best Practice 4.1: Strengthen Basic and Applied Capability of Firms and Institutions in Line with Emerging Research Frontier Trends of Industries

Pfizer: Investigator-Initiated Research, US.

- Pfizer's Investigator-initiated Research program is an incubator for R&D initiatives for developing advanced medical and scientific breakthroughs that empower third-party researchers through a syndicated collaboration program, where independent researchers across the globe are granted access to Pfizer's Centres for Therapeutic Innovation (CTI) laboratories. Under this program, researchers have access to a network of academic medical centres to work on preclinical programs.

- Some of the funding can be obtained from Pfizer and others from external parties for a wide range of R&D work, covering scientific understanding of disease, in vitro or animal studies, as well as other types of independent research on disease states, including novel diagnostic screening tools and surveys where Pfizer has no direct commercial interest. For more details refer to: Pfizer (n.d.).

Best Practice 4.2: Create Real Knowledge Transfer Partnerships

The US-China Business Council

The primary role of the partnership of the business councils in both countries is to foster strong partnership between industries in both countries to develop the industries that are critical for these countries and the global community. The key initiatives that have propelled the development of the industries in both countries are outlined below.

- Developed a Corporate IP Strategy with clear and effective implementation mechanisms in place to ensure systemic development of IP rules of engagement and development among industries in the two countries.

- Intensified education of all stakeholders on the importance of IP protection, adherence and implications of non-compliance to IP regulations.

- Ensure that there are adequate preventive measures to protect IP of firms, which include:
  - Having a balance between IPs (Patents, Trademarks & Copyrights) registered in China and overseas; and sound mechanisms in place for IP transfer to China, including licencing of international IPs to local partners.
  - Designing appropriate systems and processes to protect IP using state-of-the-art information communication technology and other detection technologies.
  - Put in place a good screening process of employees so as to prevent possibility of any future unethical behaviour.
  - Ensure business partners are vetted carefully to ensure confidentiality and respect for IP protection.
  - Put in place a strong IP enforcement body that educates enforcement officers, works in a collegial way to build good working relationships with industry and helps them acculturate the value and respect of IPs generated by other innovators, firms and entities.

- Have institutions and mechanisms in place to detect infringement of IP rights and confront IP infringement when discovered. This includes the following:
  - Inform infringers and the relevant service providers via official channels on violation and legal recourse and other implications for violation of IP rights.
  - Educate authorities on the IP regulations and prevention programs, including removing infringing goods from the market.
  - Take legal actions on firms that violate IP rules and regulations.

Best Practice 4.3: Exploit Existing Technologies and Investments Effectively to Extend Knowledge Creation

GlaxoSmithKline R&D Incentivisation Plan, UK.

- GlaxoSmithKline overhauled its bonus pay-out program to R&D researchers by decoupling it from the firm's performance. The bonus pay-out is tied to discoveries that contribute to new products and developments that are of commercial value.

- Innovators and scientists who make new discoveries are seen as key players in the initial product cycle of an IP. In this way, they are not penalised in terms of compensation when the IPs are at the tail end of the product lifecycle.

- The reward program also encourages researchers to be innovative in finding new solutions and revenue streams using existing IPs.

- Incentives are continuously adjusted to encourage continuous creation/evolution of IP. For example, when a drug reaches the proof-of-concept stage (that is, efficacy and safety of the products have been proved), a significant financial reward is given to the core team of discoverers and innovators.

Best Practice 4.4: Encourage and Facilitate Market Expansion for Large Players and Developing Niche Strategies for Small Players

Petronas Lubricants International, Malaysia.

- A very strong player in the domestic market as lubricant supplier to two major local automakers, Proton and Perodua.

- Parent company has invested significant resources to build high visibility internationally via sponsorship of world championship winning Formula 1 team.

- Build brand as factory recommended first fill fluids by leading auto manufacturer, Mercedes-AMG, and established long-term partnership with FL Selenia, Fiat Automotive and Alfa-Romeo in Italy.

- Enhanced international market reach via partnerships with Halfords Group UK (automotive parts retail & service centres) and Maruti-Suzuki (India's most popular car manufacturer) by establishing sales offices in over 30 countries.

Best Practice 4.5: Build Human Talent for Research Intensive Industries

Michigan Corporate Relations Network, US.

- This is a state wide network of 6 universities that enable corporations in the Michigan areas to access research infrastructure, experts, business outreach and support services and resources within the universities that help corporations enhance their R&D and innovation capabilities to develop the Michigan economy. Among the companies in the network are General Motors, Ford, Chrysler, Dow Corning, Dow Chemicals, Whirlpool, Lear and Kellogg Michigan.

- Small Company Internship Award – a funding scheme for small businesses to hire university students as interns on strategic projects that are important for the development of the firm and at the same time assist students acquire relevant work experience.

- Small Company Innovation Program (SCIP)/ Technology and Commercialisation Assistance (TCA) – a scheme that provides matching funds for small businesses to undertake research projects at any of the state of Michigan public universities (Michigan Corporate Relations Network., n.d.).

Best Practice 4.6: Strengthen Institutional Integration to Enhance Innovative Capacity

The Indian Pharmaceutical industry, India.

- Globally the largest generic pharmaceutical industry, accounting for 20% of global market share and expected to grow to US$100 billion by 2025.

- To strategically develop the industry in a sustainably way, key institutions (government agencies, research institutes, regulations and industry associations) were established under the "Pharma Vision 2020." The plan was established to make India a global player for the manufacturing of end-to-end drugs.

- To develop new areas such as bio-pharmaceuticals with the formation of the Department of Biotechnology in 1986 under the Ministry of Science and Technology. In July 2008 a Department of Pharmaceuticals was also established under the Ministry of Chemicals & Fertilizers.

- To foster strong cooperation and collaboration between all relevant ministries to transform the pharmaceutical ecosystem to be business friendly and efficient, the Department of Pharmaceuticals established an inter-ministerial co-ordination committee, which would periodically review, plan and enable the resolution of red-tape and constraints encountered by Indian pharmaceutical companies.

- FDI rules were relaxed for 100% ownership. This attracted leading global firms to undertake R&D in the country.

- India has the largest number of US-FDA approved labs, 1400 WHO-BMP approved plants, 253 European Directorate of Quality medicine with state of the art infrastructure.

- Large pool of highly skilled workforce with sound proficiency in English and significant resources to develop a scientific pool of researchers and establishment of several National Institute of Pharmaceutical Education and Research (NIPER) over the last few years.

- Many of the local firms serve large MNCs to meet the high standards for OECD. This gives local firms opportunity to learn from the MNCs on quality improvement standards – strong knowledge and technology transfer between local and foreign MNCs.

- Local quality and standards boards have very high and stringent requirements under the Drugs and Cosmetic Act of India and this forces firms to continuously improve their quality standards (Department of Pharmaceuticals, 2015; India Brand Equity Foundation, 2016).

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CHAPTER 5

KNOWLEDGE CONTENT OF THE RUBBER AND PLASTICS PRODUCT INDUSTRY

CHAPTER 5
Knowledge Content of the Rubber and Plastics Product Industry

5.0 Introduction

Malaysia is well-placed among the ASEAN nations as a producer of quality plastic and rubber products. Reliable access to raw materials and synergistic industries allow for cheaper production. Although the price of Malaysian plastics and rubber products and components is more expensive than its competitors, locally made plastics and rubber are preferred because of their superior quality. This is only possible because of the strong relationship between the Malaysian Rubber Board (MRB) and Malaysia Plastic Manufacturer Association (MPMA) with their respective industries and with the government.

Both rubber and plastics manufacturers share many commonalities, including similar challenges. For example, both industries are labour-intensive and dependent on a foreign workforce, both rely on OEMs, and are susceptible to losing to their competitors because of price. The susceptibility of this industry to price competition has encouraged industry players to improve their manufacturing processes and automation. While there are many challenges, opportunities exist for the Malaysian rubber and plastics industry due to goods, including white-labelled OEM products, being highly-regarded for their country of origin.

5.0.1 Rubber and Plastics Products

Rubber has a long history, dating back to 1896 when the first rubber trees were successfully planted for commercial use. Malaysia is internationally recognised as a global leader in rubber exports and in research and development, which is led by the Malaysian Rubber Board (MRB). With 20% of the world's natural rubber produced locally, the country comes in sixth in terms of natural rubber production, after Thailand, Indonesia, Vietnam, China and India. The rubber industry including natural rubber, rubber products, heveawood products and other rubber (e.g., synthetic rubber, reclaimed rubber, waste rubber, compound rubber and unvulcanised rubber etc) contributed RM30.30 billion to the national export in 2015 (Malaysian Rubber Board [MRB], 2016). In 2015, the rubber industry registered a total of 722,122 tonnes natural rubber production with 676,260 tonnes of dry rubber and 45,862 tonnes of latex rubber (MRB, 2016). About 92 percent of Malaysia's planted rubber comes from smallholders (MRB, 2016).

The heavy reliance on overseas markets for revenue means the rubber industry is subject to price and currency fluctuations caused by global demand volatility and competition from other rubber-producing nations, such as Thailand and Indonesia. However, current global demand for Malaysian natural rubber is strong because of its superior quality to that produced by its ASEAN neighbours. The shortage of local output is the main challenge for the industry, and significantly limits Malaysia's ability to take advantage of existing market opportunities arising from global demand.

The gradual decline in natural rubber production and export over the past ten years is attributed to the conversion of rubber plantations to oil palm plantations, which offer a better return on investment. Recognising the importance of rubber to Malaysia's economy, the ETP Annual Report (2014) aims to address this decline by providing grants to smallholders to improve the yield of their land by replanting old and unproductive trees. Further measures taken by the Malaysia Rubber Board (MRB) include educating smallholders on good agricultural practices and encouraging the use of higher-yielding breeds.

Although rubber output has declined, the export value of rubber products remains stable with a slight improvement in 2014, reaching RM 15.17 billion from RM14.6 billion in 2013 (MRB stats). Exports of rubber products for the first half of 2015 rose by 15.1% compared to 2014 (Matrade, 2016). Up to 70% of Malaysia's exported rubber products take the form of rubber gloves (MREPC, 2015). Malaysia remains the world's leading supplier of medical gloves, providing 50% of the global supply, the second-largest exporter of latex threads, as well as a leading producer for catheters and condoms. While much of the raw material is sourced locally, rubber product manufacturers have had to rely on importing rubber to meet the shortfall. Unfortunately, the lower quality of imported rubber leads to inferior products, compromising the global competitiveness of these manufacturers.

One of the key economic strengths of Malaysia's natural rubber aside from its global competitiveness, is its renewability. This stands in contrast to its main competitor, synthetic rubber, which is dependent on non-renewable resources. In recent years, natural rubber research has improved latex yield per hectare with new strains and also helped introduce more efficient methods of rubber-tapping.

5.0.2 Plastics

Plastic has a relatively shorter history in comparison to rubber, having only made it to large-scale commercialisation in the 1950s. Even with this short history, Malaysia has become one of the largest plastics producers in Asia, exporting its products worldwide, with principal trade partners in the European Union, China, Hong Kong, Singapore, Japan and Thailand (Plastics Industry Occupational Analysis, 2013; Foo, 2015; Plastics Technology, 2016). MPMA notes export of plastic products has grown steadily from 10% to 15% over the past ten years. The success of the Malaysian plastics industry is fuelled by the consistent supply of feedstock from Malaysian petrochemicals producers, who not only

manage to supply local plastic manufacturers but also export major petrochemical products (MIDA, 2015). The current drop in the price of crude oil has lowered resin prices and concomitantly the cost of production.

The Malaysian plastic industry is a vital contributor to the local manufacturing industry as a whole, contributing a variety of unfinished goods for strategic sectors. These include automotive components, electrical and electronic parts, telecommunications parts, construction materials, household goods, acrylic sheets, bags, bathroom accessories, battery casings, bottles, containers, and packaging materials. Figures from Plastics Technology. (2016) show the major industries for plastics demand are packaging (45%), electrical and electronics (26%), automotive (10%) and construction (8%).

While the export potential for Malaysian plastics products is immense, globalisation has also exposed plastic manufacturers to competition, in particular from China and Korea. In order to remain competitive, Malaysian manufacturers are focused on improving production cost without sacrificing quality through technological improvement, skills development and automation. It is also important for manufacturers to explore new markets and higher value products.

Malaysian plastics manufacturers are poised to advance higher up the value chain because of their positive attitude towards continuous improvement and belief in their capability to produce quality products. However, three challenges exist to hamper innovation and progress. Firstly, 90% of the plastic manufacturers are SMEs. Some of these are now in the hands of third-generation owners, some of whom are disinterested in continuing their participation in the industry. This is a major threat to the long-term sustainability of the sector. In addition, SMEs lack economies of scale, and their low capital base limits the expansion or upgrade of their manufacturing facilities. Secondly, progress for the industry is impaired by the lack of focus on design (ODM), R&D and brand development (OBM) (Lim, 2014). Lastly, the overreliance on OEMs as a quick-fix ultimately results in lower returns and opens the industry to price wars.

Public pressure on the plastics industry and the government to resolve the environmental problem caused by plastic packaging and waste has forced the industry look into sustainable and biodegradable substitutes, such as bio-plastics. To this end, MPMA has been actively campaigning for the responsible use of plastics

5.1 Key Developments and Initiatives

Plastics and rubber are industries that are relatively mature, characterised by heavy competition and low barriers to entry (plastics). The industry is also price-sensitive and labour-intensive. Being a mature industry, they need to constantly watch out for ways to improve processes (including, but not limited to, automation) or improvements in raw material (such as using synthetic rubber and bio-degradable plastic resins from tapioca). Bio-tech companies involved in plastic industries are innovators in this industry and require huge capital investment in R&D, typical of companies at the initial/growth stage.

Although plastics is not part of the 12 national key economic areas (NKEAs), it is nonetheless intrinsically linked to all sectors. Plastics and rubber have significant roles to play in the government's target to achieve 5.6% average annual growth in the manufacturing industry with a contribution of 28.5% to GDP by 2020. Although lower resin prices and the weaker ringgit are favourable to plastic manufacturers, some are diversifying to other industries, such as property development and overseas investments.[1] This diversification is driven by the competitiveness of plastic industry which makes property development and other endeavours more viable as alternative business lines.

[1] The Edge Financial Daily (2015) reported that LCTH Corp BhD is diversifying to property development in Bandar Tanjong Pinang, while Luster Industries BhD are investing in Cambodian gaming industry.

There are a number of trends that are impacting the national rubber and plastics industry, notably:

- **Liberalisation of Trade**. The establishment of ASEAN as a single market under the ASEAN Economic Community's free-trade pact (AEC) in 2015 will help stimulate growth in the manufacturing industry with greater access to intra-regional and global trade. Although the AEC will open new markets, it will also expose Malaysia to renewed competition across the region.

- **Environmental Concern**. Global warming and environmental degradation from manufacturing waste and plastics consumption were highlighted as pressing issues for this century. In response to the growing environmental concern, governments have introduced regulations to ensure the use of sustainable manufacturing processes and materials. For example, the use of plastics is regulated by the Registration, Evaluation and Authorisation of Chemical Substances (REACH) or Waste Electrical and Electronics Equipment (WEEE) initiated by the European Union (EU) and other economies.

- **Government Incentive to Automate.** The automation capital allowance of 200% on the first RM4 million in expenses incurred within the 2015-2017 period provided by the government under the Economic Transformation Programme will likely incentivise the mechanisation of affected labour-intensive industries such as rubber products, plastics, wood, furniture and textiles.

- **Development of Technology Parks**. The establishment of fully-equipped specialised technology parks to accommodate greenfield MNC operations in Malaysia will open new avenues for investment in the plastics and rubber products industry. This will also encourage local firms to adhere to international standards and strengthen their competencies with the aim of potentially increasing exports.

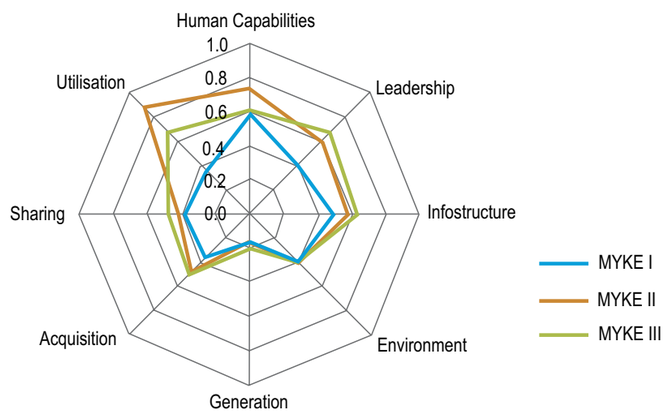
- **Third Industrial Master Plan (IMP3).** The strategic industries targeted for development leading up to 2020 are fundamentally linked to rubber and plastics industries – non-resource-based industries comprise E&E, medical devices, transport equipment; resource-based industries comprise petrochemicals, rubber, and food processing. This plan is part of the government's aim to grow the manufacturing industry by 5.6% annually and have it contribute 28.5% of the nation's GDP by 2020.

- **Synthetic Rubber.** With a ready supply of feedstock from the petrochemical industry, Malaysia is increasing its investment into the development of specialty chemicals, such as synthetic rubber. In response to the growing demand of synthetic rubber in Asia, a joint venture was established between Ube Industries, Ltd., LOTTE CHEMICAL CORPORATION, Lotte Chemical Titan Holding Sdn. Bhd., and Mitsubishi Corporation to manufacture and market butadiene rubber (BR) in Johor, Malaysia.

5.2 Knowledge Content

The knowledge resource foundations provide guidance as to the level and trajectory of development of the rubber and plastics industry. **Figure 5.1** shows changes that have taken place over the period 2003 to 2014, at the three periodic milestones defined by the MYKE I, II and III assessment. The industry has demonstrated little-to-no progress along the dimensions of the two categories of Knowledge Enablers and Knowledge Actions over the MYKE II and MYKE III period.

Figure 5.1: Overview of Knowledge Enablers and Knowledge Actions for MYKE I, II and III



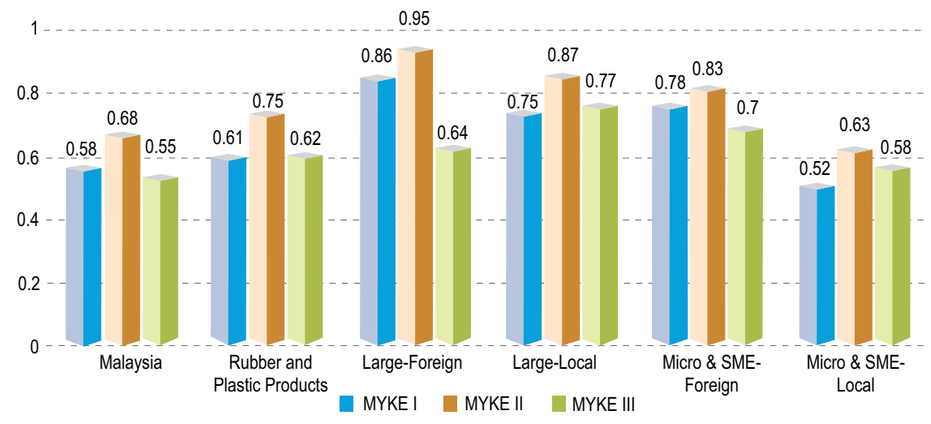
5.3 Knowledge Enablers

5.3.1 Human Capabilities

The 11th Malaysia Plan's inclusion of human capital development as a strategic thrust is well- timed given the lacklustre performance of human capabilities in the country. As expected, this is also evident in the rubber and plastics industry, although the industry has performed satisfactorily in comparison with the Malaysian aggregate. As an industry, human capabilities improved from an index of 0.61 in 2003 to 0.75 in 2007, but regressed to an index of 0.62 in 2014.

All firms, regardless of size and type, have not improved their human capabilities resource. Large foreign firms have lost much of their ability to attract skilled talent, and shrunk from an exemplary score of 0.95 in the MYKE II period to 0.64 in MYKE III, which is lower than large local firms (0.77) and small foreign firms (0.70). Local SMEs are poorest in terms of attracting and building talent, possibly because SMEs are most reliant on unskilled labour in their manufacturing processes. This industry faces stiff competition for talent from other verticals and generally loses out because of its poor working environment, which is associated with unkempt factory floors. While the level of education required to work in this industry has somewhat risen from MYKE I, it may not have reached the level requiring specialised VTEC or degrees unless the factories continue to increase the level of automation and improve working conditions.

Figure 5.2: Human Capability of the Rubber and Plastics Product Industry

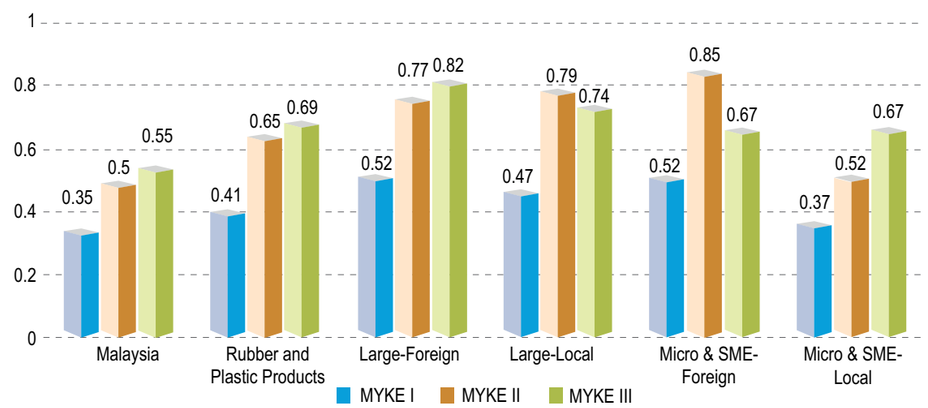


5.3.2 Knowledge Systems and Leadership

The Malaysian rubber and plastics companies show positive improvement over the three MYKE periods in terms of formal approaches to knowledge management by developing strategies, structures, systems, processes and committees for knowledge capture, generation and use. **Figure 5.3** shows that the rubber and plastics industry is above the aggregate for Malaysian industry in its approach to knowledge management. However, while all firms improved significantly from 2003 to 2007, only large foreign and local small firms were able to maintain a consistent level of improvement through to 2014.

Any gaps in a firm's systematic approach to knowledge appears to be related to firm size rather than its status as a foreign or local firm. Large firms, foreign (0.82) or local (0.74), are performing above the industry aggregate of 0.69, while the small firms (both foreign and local scoring 0.67) are performing just below the industry aggregate. However, from the trend over the three periods, it is the local SMEs that have made the most progress in knowledge leadership, from being the lowest in the industry at 0.37 in 2003, to being around the same level as small foreign firms at 0.67, which is above the national aggregate.

Figure 5.3: Knowledge Leadership in the Rubber and Plastics Product Industry



5.3.3 Technology and Infostructure

Over the three MYKE periods, technology and infostructure of Malaysian rubber and plastics firms improved consistently and at a similar rate to the national aggregate. The rubber and plastics industry is just slightly below the national aggregate at 0.62, compared to the national aggregate of 0.65. For a manufacturing industry which is heavily reliant on manual, unskilled labour, it is impressive that all firms, whether it is foreign or local and irrespective of size, have made significant progress in improving the availability of computers to their employees.

5.3.4 Knowledge Environment

As a whole, the rubber and plastics firms show an average level of engagement with the broader institutional knowledge environment, and no improvement over the three MYKE periods. Large firms, both foreign and local, slightly improved their level of engagement between MYKE II and MYKE III (from 0.41 to 0.42), while foreign small firms leaped from 0.37 to 0.47. However, this is offset by poor performance within the local SME sector (below the national aggregate), thus resulting in industry-wide stagnation.

Figure 5.4 Technology and Infostructure of the Rubber and Plastics Product Industry

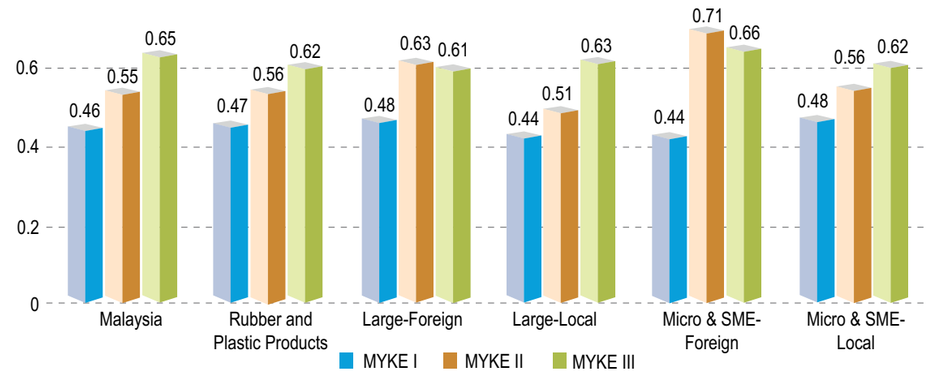
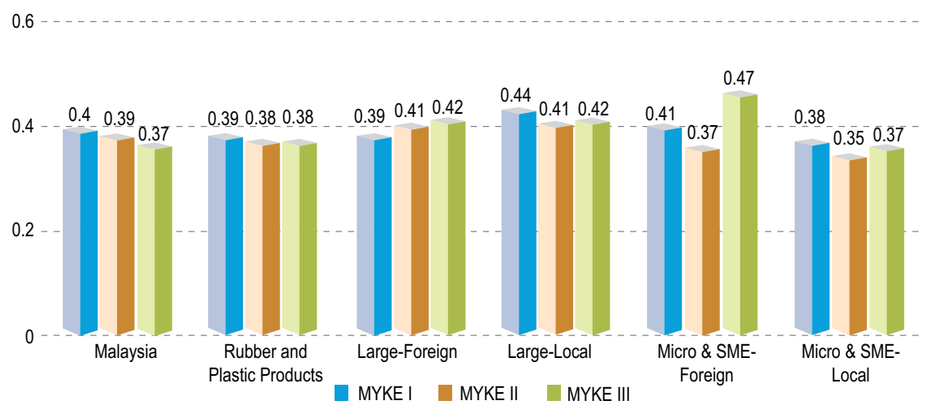


Figure 5.5 General Environment Awareness of the Rubber and Plastics Product Industry



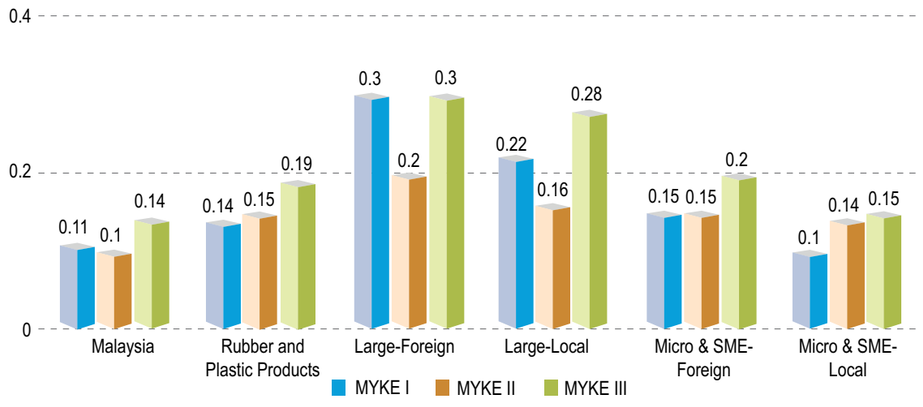
The rubber and plastics industry is nonetheless making an effort to engage with their associations, institutions and government to improve efficiencies in their industry. Although local SMEs are not as progressive as other firms, they are improving incrementally, showing an awareness and knowledge of Government plans and initiatives. In 2014, small foreign firms in particular appear to have the most engagement with the knowledge environment. It is encouraging that this industry continues to engage in the knowledge environment to a level which is similar to the national aggregate even though it is perceived as a low-tech manufacturing industry and is not part of the country's priority industries.

5.4 Knowledge Actions

5.4.1 Knowledge Generation

The rubber and plastics industry is only slightly better at knowledge generation than the Malaysia aggregate. The industry has shown incremental improvement over the three MYKE periods – from 0.14 in 2003, to 0.15 in 2007 and 0.19 in 2014. Over this period, large local and foreign firms are more likely to engage in knowledge creation through engagement with and in R&D, patents and copyrights. Small foreign firms also attempt to engage in knowledge creation, albeitat a lower level compared to larger firms. However, small local firms remain relatively weak in knowledge generation in comparison to the rest of the firms in this industry. This pattern confirms that larger firms have more resources and opportunities for R&D than the small local firms. The low level of knowledge creation is also reflective of the nature of the industry which has a focus on manufacturing OEM, and a lower emphasis on R&D. This however is changing, with both the rubber and plastics associations and the government agencies taking strides towards encouraging knowledge and innovation among the industry players.

Figure 5.6 Knowledge Generation Activity in the Rubber and Plastics Product Industry

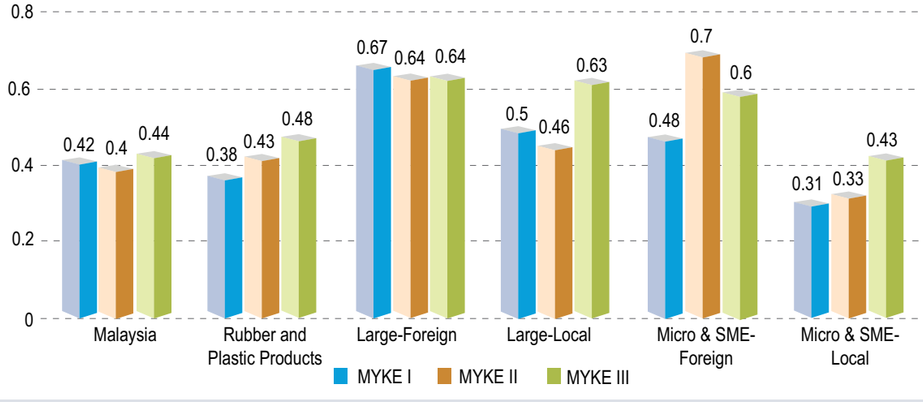


5.4.2 Knowledge Sharing

The rubber and plastics industry started off with a lower knowledge sharing index than the national aggregate in 2003, but progressed ahead of the national aggregate in 2007 and 2014. This incremental improvement in knowledge sharing (0.38 to 0.43 to 0.48 over the three periods) is heartening given that the sector, particularly rubber, is perceived as a sunset industry.

The biggest improvement on knowledge sharing comes from large local firms which are catching up quickly with foreign firms. In the latter, large firms have stagnated while smaller ones have declined entirely, from 2007 to 2014. Small local firms also increased their knowledge sharing activities over the three MYKE periods. The results suggest that local firms are building their knowledge capabilities and scaling up their competencies to remain competitive, while foreign firms are scaling back on their knowledge sharing activities.

Figure 5.7 Knowledge Sharing Activity of the Rubber and Plastics Product Industry



5.4.3 Knowledge Utilisation

All rubber and plastics firms, regardless of size or registration location, have made a concerted effort at knowledge utilisation. Starting from a low base in 2003 to 2007, firms have made strong headways in leveraging the knowledge they possess to create measurable outcomes. In its entirety, the rubber and plastics industry has outpaced the national aggregate in knowledge utilisation.

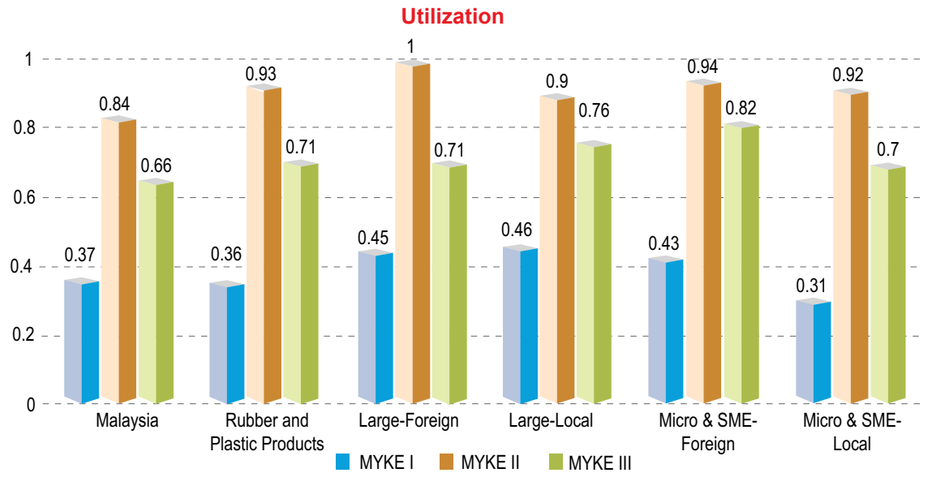
Interestingly, all firm categories in the sector have made excellent progress over the period 2003 and 2007 where knowledge utilisation have generally doubled (and in the case of the small local firms, almost tripled). However, firms were not able to sustain the momentum and knowledge utilisation declined over the next MYKE period to 2014. The decline, however, is not substantial enough to be of statistically significant as all firms appear to be engaging at a similarly healthy level of knowledge utilisation in 2014.

There was some progress from MYKE I to MYKE II in some elements of knowledge enablers (human capabilities, leadership, infostructure) and knowledge actions (utilisation and sharing), but advancement ceased in MYKE III and in some cases, even regressed; human capabilities and knowledge utilisation show the strongest decline from 2007 to 2014. However, the industry is either ahead or on level footing with the Malaysian aggregate. Overall, although there were some setbacks between the MYKE II and MYKE III assessment periods, the rubber and plastics industry appears to be gradually advancing in its development of knowledge resources.

Human capabilities is an issue in the rubber and plastics manufacturing industry because of the difficulty in attracting skilled talent to work in an industry which is perceived as less exciting and appealing especially when measured against service industries like tourism and retail. In addition, most of the workers employed in rubber and plastics industry are unskilled or semi-skilled, with little need for training and with no requirement for degrees. However, as the industry becomes more technologically advanced with the advent of automation, the need for strong technical proficiency over low-cost wage labourers is essential.

The initial rise in technology and infostructure from 2003 to 2007 suggests a move toward automation but there was little advancement in 2014. Similar to other industries, knowledge utilisation significantly declined by MYKE III after a sharp increase over the MYKE I and MYKE II periods. While the decline is sharp, knowledge utilisation is still at a healthy level for the industry at 0.71, and is at a level above infostructure.

Figure 5.8: Knowledge Utilisation Activity of the Rubber and Plastics Product Industry



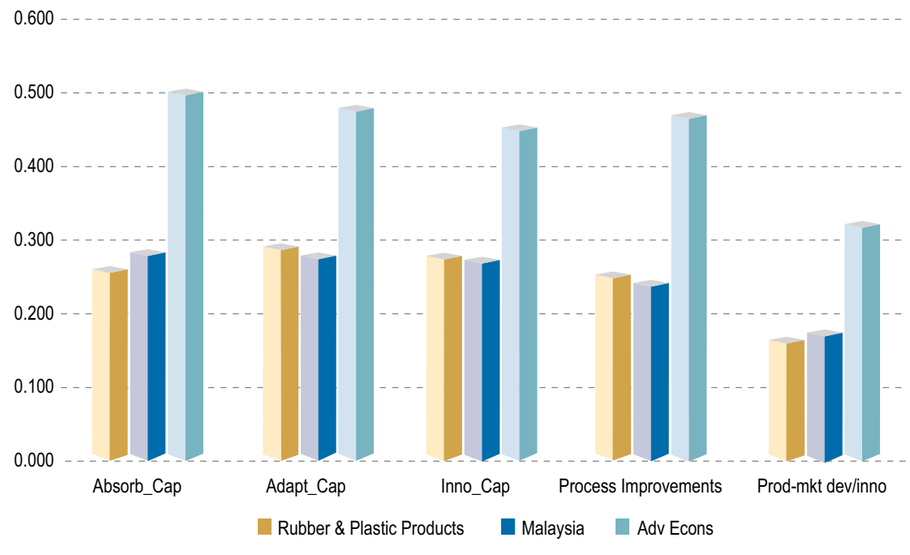
Consistent improvement has taken place in local SMEs. Other than human capability, these firms have shown incremental advancement in building their knowledge resource foundations. This positive trend may be a result of the government initiatives to assist local SMEs. The trend in building knowledge resources across the three MYKE assessment periods suggest that there is some progress in knowledge creation and innovation in the rubber and plastics industry.

5.5 Dynamic Capabilities Profile for Rubber and Plastics Product Industry

This section examines dynamic capabilities of the rubber and plastics industry to understand whether firms in the industry have the necessary capabilities and resources to respond and adapt to competition and changes in the external environment. Essentially, the three main components of dynamic capabilities are absorptive capability, adaptive capability and innovative capability. Firms with high levels of dynamic capabilities are able to better respond to competition and environmental change by adapting and developing or using their core competencies to strengthen their market position.

It is evident from **Figure 5.9** that the rubber and plastics industry's positive dynamic capabilities are a result of the industry's positive, albeit slow, progress in building its knowledge resource foundations over the three MYKE periods. It is observed that the industry is well ahead of the Malaysia industry aggregate in terms of its adaptive and innovative capabilities but falls behind the Malaysian industry aggregate in its absorptive capability. The industry's positive position in adaptive and innovative capabilities has produced process improvements in manufacturing technology (automation), management methods and marketing strategies. However, it is apparent that the industry is less successful in new-to-market product innovation.

Figure 5.9 Dynamic Capability Profile of the Rubber and Plastics Product Industry



5.5.1 Absorptive Capability

The results suggest that the rubber and plastics industry is not as efficient as other Malaysian industries in systematically gathering, storing or transferring market and technological information (absorptive capability). Being an industry that is focused on manufacturing and OEM, it is more production rather than marketing oriented; for example, there is little scanning of the market environment to understand customer needs.

Figure 5.10 shows firms in the rubber and plastics industry get their information from numerous sources. Notwithstanding the above, the intensity of its knowledge gathering is not outstanding aside from the top five sources (suppliers, customers, conferences, other units within the firm and competitors), which is higher than the Malaysian aggregate. The results reveal that both suppliers and customers are of almost equal importance as sources of knowledge, indicating the importance of close relationships between these players in the industry. This is essential as the OEMs' main focus is ensuring high quality products and reduction of manufacturing costs through efficient processes. These five knowledge sources, plus external accreditation and certifications, journals and technical reports and commercial R&D lab are used at a slightly higher level than the Malaysian aggregate. The results also reveal little knowledge acquisition from universities or government research organisations, and M&As.

5.5.2 Adaptive Capability

A firm's adaptive capability highlights its ability to use its knowledge to respond and adapt to its competitive environment. A high score suggests that firms have the necessary systems to use their knowledge and possess the capability to configure resources and structures to meet the demands of marketplace changes. The adaptive capability profile of the rubber and plastics industry is slightly higher than the Malaysian aggregate, suggesting that firms are investing appropriately to develop human capital and improving processes and structures to be able to respond to new opportunities.

Figure 5.11 shows the skills profile of firms in the industry. The results suggest the industry has a significant pool of skills in business and administration which is much higher than the Malaysian aggregate. It is unsurprising that E&E and general engineering have a relatively strong presence. The rubber and plastics industry employ more natural sciences and biotechnology talent than the Malaysian aggregate, reflecting the importance of research and development in rubber and plastics in particular. The results suggest that the industry recognises the importance of science and technology and is moving towards building their capabilities in R&D. The progress in building biotechnology skills, which is essential for both rubber and plastics industry to remain competitive in the global market, is encouraging.

The institutional environment plays an important role in assisting firms to develop their capabilities. There are numerous public and private institutions in Malaysia which offer opportunities for firms to build human capability in various forms, through avenues like training, education, skills upgrading, business advice, marketing, and research commercialisation (see **Figure 5.12**). The results suggest a low level of engagement with the institutions for building human capability, with a lower index across all types of information or advice, except for quality management and research commercialisation.

Figure 5.10: Sources of Knowledge in the Rubber and Plastics Product Industry

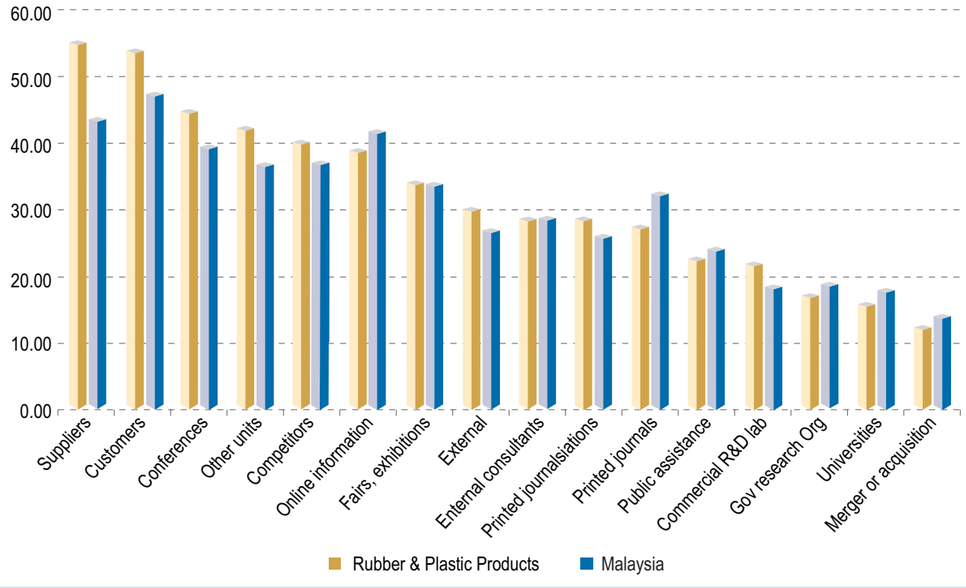


Figure 5.11: Skills Profile of the Rubber and Plastics Product Industry

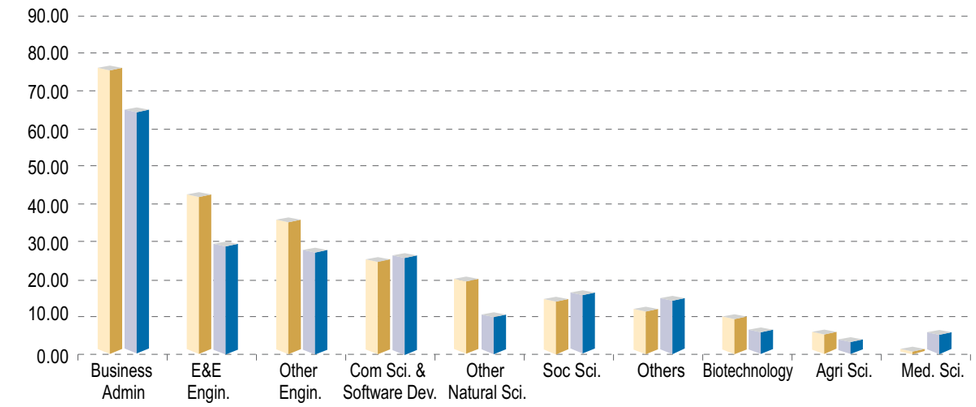
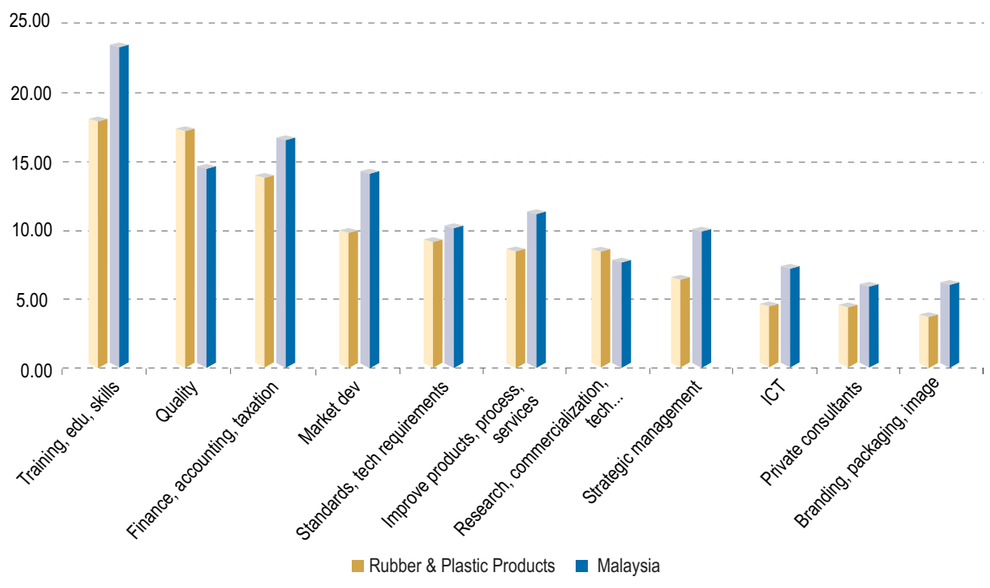


Figure 5.12: Role of Institutional Environment in Skill-Building of the Rubber and Plastics Product Industry



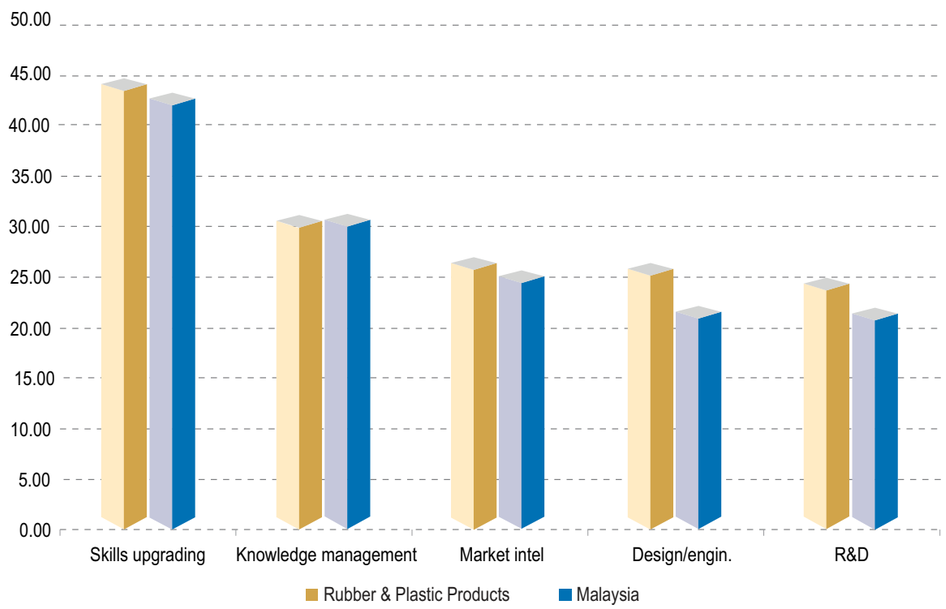
5.5.3 Innovative Capability

Innovation outcomes require more than having the available resources and market knowledge. Firms also need to be able to integrate its resources and existing knowledge with new knowledge to generate insights and capabilities to adapt in order to quickly seize new opportunities. Firms with a high level of innovative capability have the ability to assimilate external knowledge into their organisations (people and processes) which can then be used to create new products and services to meet changing customer needs.

The dynamic profile of the industry shows that although firms are less active in acquiring technology from external sources (absorptive capability), they are slightly more active in leveraging existing technological capability in the development of improved, new products (innovative capability) than the Malaysian aggregate. A possible reason could be that the industry, in particular the Malaysian rubber manufacturing industry led by MRB, is a global leader in rubber research. Hence, there is lower need to acquire technology externally, and the focus is then trained on improving the industry's own technological capability to take advantage of future opportunities.

The industry is making attempts to continue improving its adaptive capability by investing into skill upgrading, which stands at a slightly higher level than the Malaysian aggregate. Despite its score, the industry's attempt at gathering market intelligence is still relatively low. However, its involvement in design and engineering and R&D are at levels higher than the national aggregate, which should lead to future breakthroughs in product innovation (Figure 5.13).

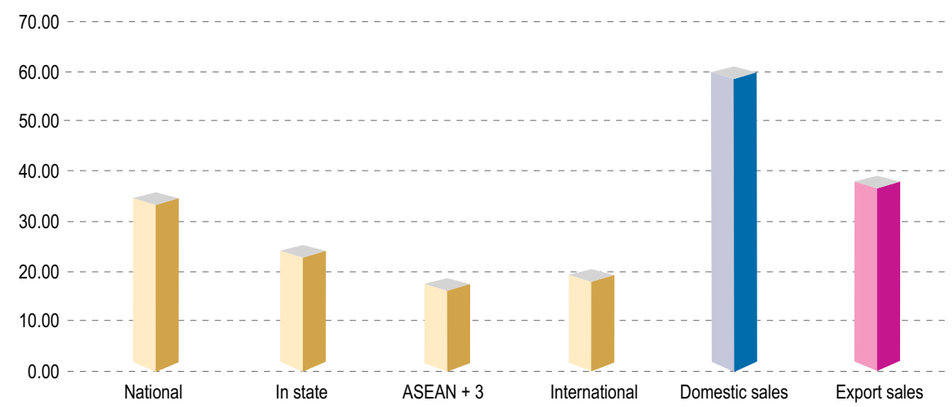
Figure 5.13: Knowledge Intensive Activities in the Rubber and Plastics Product Industry



5.6 Outcomes of Dynamic Capabilities in the Rubber and Plastics Product Industry

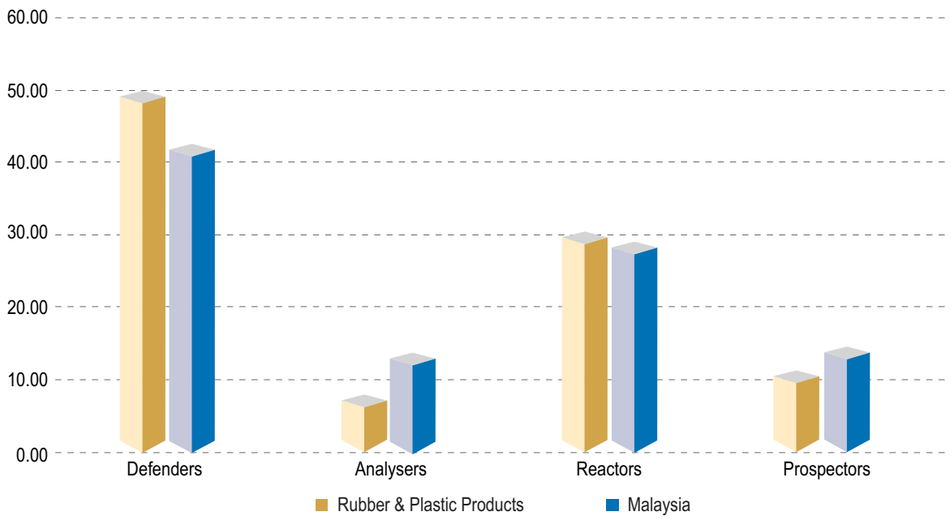
The Malaysian rubber and plastics industry has a global reputation for its high quality products and efficient manufacturing processes and its use of superior raw materials. Its reputation is reflected in **Figure 5.14** which shows Malaysia's relatively strong international presence, where nearly 40% of its products are exported, with about 21% being international and 18% regional (ASEAN plus China, Japan and Korea). However, with just over 60% of the products sold domestically, the industry is still quite reliant on the home market for its revenue, where 36% of its revenue originates from within the state and 25% from national sales. It is likely the export figure is driven down by the plastic products since a high proportion of Malaysia's rubber products are exported. Malaysian Rubber Export Promotion Council Home [MREPC] (2015) reported that Malaysia supplies 50% of the world's supply of medical gloves, and is also the world's leading supplier of Foley catheters and the second-largest exporter of condoms and latex threads to over 190 countries, with an export value of almost RM15 billion. In contrast, the export value of plastics is only just approaching RM12 billion.

Figure 5.14: Market Presence of the Rubber and Plastics Product Industry



Note: The results are based on survey data.

Figure 5.15: Strategic Profile of Firms in the Rubber and Plastics Product Industry



The strategic profile of the rubber and plastics industry reveals the predominance of Defender companies in the industry, making up to 50% of firms, which is higher than the Malaysian aggregate. Such organisations prefer to protect their current markets rather than seek new opportunities, thus they focus on a few, selected products and concentrate on refining quality and efficiency. Reactor companies make up the next major group of companies with 30.4%, which is only slightly higher than the Malaysian aggregate. Reactors do not anticipate or influence change, and instead only respond to changes in the marketplace when their positions are threatened. Prospectors and Analysers make up smallest groups, and are below the Malaysian aggregate (11.5% and 8.1% respectively). An industry where 80% of firms are not opportunity-seekers is of concern because of the growing intensity of competition in the export market from several ASEAN countries.

5.7 Relationships between the Key Blueprints of the Rubber and Plastics Product Knowledge Ecosystem

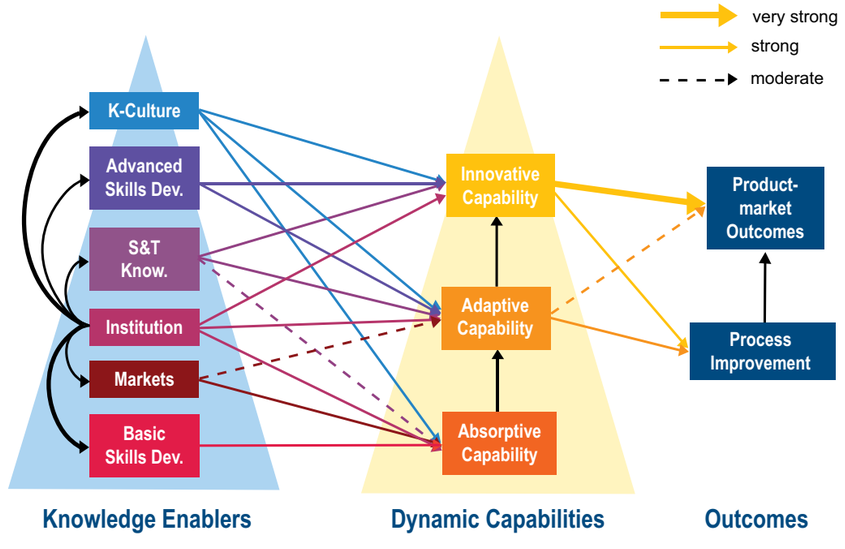
This section scrutinises the impact of knowledge enablers on dynamic capabilities and its subsequent impact on economic outcomes for the rubber and plastics product industry. In making a meaningful comparison, the knowledge ecosystem for the Malaysian rubber and plastics product industry is comparatively assessed relative to the rubber and plastics product industry in advanced sector countries (e.g. Germany, Japan, Russia, and United States). Through content analysis of in-depth interviews and data obtained from DOS, the rubber and plastics product industry is categorised as an Adapter in Malaysia. Firms in the Malaysian rubber and plastics product industry do not possess the level or type of knowledge that firms in Pace-setter industries possess. Nonetheless, there is sufficient knowledge that can be used from the advances made by Pace-setters and other firms to innovate in ways that are able to capture significant market share. As such, most rubber and plastics product firms tend to be fast followers, quickly seizing opportunities and turning them to their advantage, often supplanting Pace-setters in the process.

The knowledge ecosystem for the rubber and plastics product industry in advanced sector countries is illustrated in **Figure 5.16.** From this figure, it is observed that the knowledge ecosystem for rubber and plastics product firms in advanced sector nations facilitates the development of all three components of dynamic capability. This, in turn, drives both process innovations as well as product innovation. In particular, firms in the rubber and plastics product industry in advanced sector countries are strongly attuned to the external marketplace and exhibit strong absorbability capability. These firms employ market and customer knowledge to good effect through a process of internal adaptation in response to external opportunities, which is a reflection of adaptive capability. The strong absorptive and adaptive capabilities of rubber and plastics product firms in advanced sector countries allows them to build innovative capability to create improvements in their processes as well launch products that satisfy customer end-needs globally.

The knowledge ecosystem for the rubber and plastics product industry in Malaysia is depicted in **Figure 5.17**. This figure shows that the knowledge ecosystem for firms in the Malaysian rubber and plastics product industry is significantly weaker than that of advanced sector countries. Several notable differences between the rubber and plastics product industry in advanced sector countries against that in Malaysia can be observed.

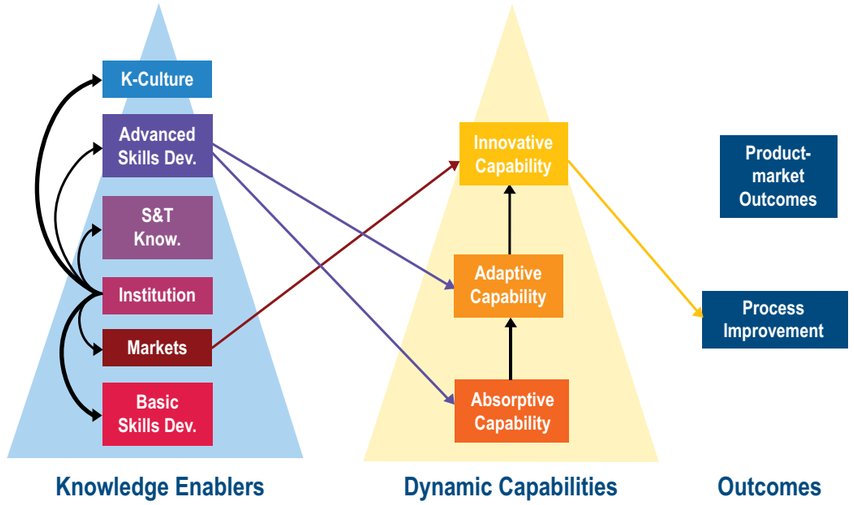
More specifically, the overall dynamic capability position of rubber and plastics product firms in advanced sector countries is strong. These firms possess strength in many ways. A rich tapestry of enablers is also observed in the nurturance of the different dynamic capabilities in the rubber and plastics product industry for advanced sector countries. In contrast, dynamic capabilities of rubber and plastics product firms in Malaysia are weakly nurtured as markets tend to drive innovative capability. Absorptive capability of rubber and

Figure 5.16: Knowledge Ecosystem of the Rubber and Plastics Product Industry in an Advanced Country



Note: Very strong impacts are represented by the bolded line, strong impacts are represented by normal lines and moderate impacts are represented by dotted lines.

Figure 5.17: Knowledge Ecosystem of Rubber and Plastics Product Industry in Malaysia



plastics product firms in advanced sector countries is built through market sensing, and it is only after this step that its transposition into innovative capability through internal adaptation and readiness of firms to take advantage of absorptive intelligence occurs. These firms leverage on their internal competencies and deliver products that closely match market needs, and their strength in adaptive capabilities enables them to create process efficiencies. In sharp contrast, as firms in the Malaysian rubber and plastics product industry lack strength in adaptive capability, they are not able to release globally competitive novel products. They tend to focus on absorbing knowledge and understanding technical advances made by others instead of engaging in break-through advances in products themselves. As such, the innovative capability of firms in the Malaysian rubber and plastics product industry is such that it can only produce process improvements, but not globally competitive new products.

A significant collaboration with universities, research institutes and other knowledge-led institutions takes place among rubber and plastics product firms in advanced sector countries, and through this process firms are able to nurture absorptive, adaptive and innovative capabilities. This appears to be weak within the Malaysia setting. More specifically, S&T is weak and institutions do not have any direct impact on components of dynamic capability in the Malaysian rubber and plastics product industry. Efforts for skills development in the Malaysian rubber and plastics product industry continue to suffer from S&T weaknesses, which results in significant opportunity costs for the industry.

The weaknesses in the Malaysian rubber and plastics product industry's knowledge ecosystem in developing the necessary strength across all three dynamic capability components is seen in **Figure 5.17**. As a result of deficiencies, firms in the Malaysian rubber and plastics product industry are only able to create process improvement but fail to materialise significant product innovation. Thus Malaysian firms compete primarily on the basis of price in existing product markets rather than through development of premium and high value-add products.

A summary of the comparative standing of the knowledge ecosystem of the rubber and plastics product industry in advanced sector countries and in Malaysia is provided in Table 5.1. This table highlights the key areas of comparative deficiency of the Malaysian rubber and plastics product industry's knowledge ecosystem relative to the strengths found in advanced sector countries

Table 5.1: Knowledge Enablers and Dynamic Capabilities for the Rubber and Plastics Product Industry

Advanced Countries	Malaysia
Basic skills have a **positive impact** on absorptive capability. This study finds that the level for basic skills required for high-end rubber and plastics product processes are high in advanced sector countries. These countries have a long history of accumulated knowledge. Government agencies, regulatory authorities, industry associations and institutions of learning drive the development, nurturance and dissemination of knowledge in the rubber and plastics product industry in advanced sector countries.	Basic skills **fail to show a significant impact** on absorptive capability. This study finds that firms in the rubber and plastics product industry in Malaysia rely heavily on low skill labour force that comprises a significant number of foreign labourers. Transitory employment prevails as many workers are not local. In turn, this results in non-systematic contributions to absorptive capability. This inadequacy needs to be tackled in order to lay a stronger absorptive capability foundation for effective feeding into the higher components of dynamic capability.
Market intelligence has a strong **positive impact** on absorptive capability and a **moderate impact** on adaptive capability. The study finds that suppliers, customers, competitors, external consultants and commercial R&D centres play a significant role in the absorption of new knowledge (especially the use of new technology) in the rubber and plastics product industry in advanced sector countries, which suggests that a nexus of collaboration and intensive sharing is present, and in turn, conduces the development of new technologies, systems and processes. As such, the combination of myriad sources of knowledge aids the development of technologically advanced materials and variety of high value-added rubber and plastics products.	Market intelligence has a **positive impact** on innovative capability. The study finds that suppliers, customers, competitors, external consultants and commercial R&D centres inform the innovation agenda in the Malaysian rubber and plastics product industry. However, there is degree of insufficiency in dynamic capabilities and knowledge base to materialise the innovation agenda into novel high value-add products. Instead, most firms in the rubber and plastics product industry in Malaysia are only able to employ such knowledge to create process improvements in order to become price competitive.
Institutions are **strong enablers** of the knowledge ecosystem and have a **direct strong and positive impact** on all three components of dynamic capability.	Institutions are **indirect enablers** for all the different knowledge enabling components, but they **do not have any direct impact** on these dynamic capability components.
Institutions, such as industry associations, government research institutions and universities, play a key role in creating a vibrant knowledge ecosystem that nurtures the dynamic capabilities of firms in the rubber and plastics product industry. Institutions act as direct enablers of skills development, talent upgrade and leading-edge	The study finds that institutions, such as industry associations and universities, play an important role in training talent for the Malaysian rubber and plastics product industry. However, institutions in Malaysia do not produce any direct improvements in the components of dynamic capability in the Malaysian rubber and plastics product industry.

Table 5.1: Knowledge Enablers and Dynamic Capabilities for the Rubber and Plastics Product Industry (cont'd)

Advanced Countries	Malaysia
R&D that produces products and services of the next generation, thereby sustaining the long-term future of the industry.	
S&T knowledge has a **positive and moderate impact** on absorptive capability, and a **positive and strong impact** on adaptive and innovative capabilities. Firms in the rubber and plastics product industry in advanced sector countries are highly focused on producing technical advances as part of advanced engineering, materials science and R&D efforts. Such a focus enables these firms to be at the forefront in developing new systems, products and services. Strong foundations in basic and applied research in science, technology and engineering enables these firms to also discover broad cross-cutting applications for their advanced rubber and plastics.	S&T knowledge has a **no direct impact** on absorptive, adaptive and innovative capabilities. S&T only has **indirect effects** through its interaction with other enabling factors. Most firms in the rubber and plastics product industry in Malaysia are users of new technologies or innovations that have been developed by others elsewhere. The key influence of S&T is observed via personnel with advanced skills, who take on the role of understanding knowledge and technical advances from others and adapting them for use and applications in markets, particularly in the Malaysian market. Much of the S&T knowledge in the Malaysian rubber and plastics product industry is handled by a small group of scientists and R&D personnel (and not widespread within the firm).
Advanced skills have a **positive and strong impact** on innovative and adaptive capabilities. Resources in advanced sector countries are significantly allocated to improve the quantity and quality of the industry's workforce, especially in the development of specialist areas and higher degrees aligned with the current and changing needs of the rubber and plastics product industry. Considerable emphasis is also given to charting future possibilities for the industry. Existence of a strong 'quadruple-helix' enables many rubber and plastics product firms with sound theoretical knowledge to reconfigure and employ knowledge to improve reliability and efficiency of rubber and plastics processes and improve and extend product range and applications into new areas.	Advanced skills have a **positive and significant impact** on absorptive and adaptive capabilities. The impact of advanced skills in the Malaysian rubber and plastics product industry is inclined toward the lower level components of dynamic capability in the form of absorptive and adaptive capabilities (rather than toward the higher levels of adaptive and innovative capabilities). Compared to advanced sector countries, there is a difference in the focus of attention or a deficiency in the quality and quantity of advanced skills involved in enabling innovative capability and its associated product outcomes. This deficiency needs to be addressed by paying attention to the quantum and quality of personnel and the focus of knowledge application and leverage within the Malaysian rubber and plastics product industry. At the present moment, the workforce in the rubber and plastics product industry are translators or users of new technology, and thus they are not producers of cutting-edge knowledge and applications.

Table 5.1: Knowledge Enablers and Dynamic Capabilities for the Rubber and Plastics Product Industry (cont'd)

Advanced Countries	Malaysia
Knowledge culture has a **positive and strong impact** on absorptive, adaptive and innovative capabilities. This study finds that the organisational culture of rubber and plastics product firms in advanced sector countries is strongly geared toward rapid learning of the most recent advances. Having a nuanced understanding of the marketplace, most rubber and plastics product firms are able to create fine-tuned adaptations that closely match the needs of end customers and clients. Many firms are geared up to move quickly by incorporating enhancements that closely align with market needs. This is a characteristic of their success. These firms are observed to build unique aspects into their dynamic capability DNA. This knowledge culture produces strong dynamic capabilities used to create new products or services that possess enhanced features demanded by the marketplace at affordable prices for target segments.	Knowledge culture **does not feature as key driver** in the nurturance and development of absorptive, adaptive and innovative capabilities. This study finds that the organisation culture of rubber and plastics product firms in Malaysia is strongly hierarchical, whereby innovation and R&D activities are confined to select individuals or a small department within their firms, and only minimal resources and investments are channelled into R&D activities. In most instances, the responsibility for innovating is left for higher divisions within the firm's hierarchy or specialists that are brought in specifically for the task, and thus diminishes the internal innovation imperative. This leads to negligible firm wide dynamic capability building. As a result, most rubber and plastics product firms in Malaysia tend to only modify existing products and services to improve price competitiveness. Little to no ground-breaking work is done.
The continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** Sound R&D and strong workforce with basic, technical and R&D experience help the rubber and plastics product industry in advanced sector countries to stay resilient in terms of their dynamic capabilities. A strong knowledge foundation enables rubber and plastics product firms to adapt external knowledge and incorporate it into new innovations that improve processes and enhance quality of existing products and services. Rubber and plastics product workers in advanced sector countries often possess extensive experience in the sector and feature as key personnel in the translation of internal and external knowledge into new products and services. Intensification of technology and knowledge capabilities among rubber and plastics product firms in advanced sector countries results in new process improvements that translate into new lines of products and services for the domestic and international rubber and plastics product industry.	The continuum from absorptive capability to adaptive capability to innovative capability **is present.** The skill composition of the rubber and plastics product industry in Malaysia consists of a large number of low skill talent and only a small segment of highly skilled trained talent. Even though there is some degree of sufficiency to build dynamic capabilities, the quantity and quality of talent with specific skills for innovation (in the form of higher order adaptive and innovative capabilities) require considerable strengthening.

The transformation of dynamic capabilities to economic outcomes for the rubber and plastics product industry in advanced sector countries and in Malaysia is provided in **Table 5.2**. This table shows that that the impact of the components of dynamic capabilities on economic outcomes for the rubber and plastics product industry in advanced sector countries and in Malaysia differs significantly.

Innovative capability in advanced sector countries was found to have a positive impact on new product development and process improvement. Similarly, adaptive capability in these countries plays an important role in both process improvement and new product development. Notably, a very strong positive flow from process innovation to product innovation is present in the knowledge ecosystem of the rubber and plastics product industry in advanced sector countries. This indicates that process innovation features as a significant enabler that allows firms in this industry to not only complete on new product features but also on cost effectiveness.

However, only innovative capability is observed to have a significant impact on outcomes in the Malaysian rubber and plastics product industry. Moreover, this effect is solely directed at process improvement. This suggests that Malaysian firms are primarily geared for price competition rather than product innovation. Weaknesses in dynamic capability, namely poor innovative capability to create new products and the absence of strong adaptive capability effects indicate weakness in the global competitiveness of Malaysian firms' high value rubber and plastics products.

Table 5.2: Dynamic Capabilities and Economic Outcomes for the Rubber and Plastics Product Industry

Advanced Countries	Malaysia
Adaptive capability has a **positive impact** on process improvement and product-market innovation. The adaptive capability of firms in the rubber and plastics product industry in advanced sector countries plays an important role in driving process-led efficiencies that launch globally competitive new products and services. Firms in the industry are highly capable of adapting new technologies and scientific advances to produce customised high value-add applications for local and global markets.	Adaptive capability has no impact on process improvement and product market innovation. This study finds insufficient strength and depth in the components of dynamic capability among firms in the Malaysian rubber and plastics product industry. Adaptive capability of rubber and plastics product firms in Malaysia fails to deliver significant benefits as a result of weaknesses in its enabling factors. Potential gains, in terms of process improvement or new product enhancements, could be accessed if adaptive capability position was stronger and correctly leveraged is lost.
Innovative capability has a **positive impact** on product market outcomes and a **moderate impact** on process improvement. In advanced sector countries, strong innovative capability is powered by strength in S&T base, high R&D investment and strong interaction and collaboration among stakeholders in the rubber and plastics product industry contributes to technical and scientific advances that can be embedded into the production of rubber and plastics to create a wider range for their application.	Innovative capability has an **impact** on process improvement, but **does not produce any impact** on product market outcomes. This study finds that the focus of firms in the Malaysian rubber and plastics product industry is strongly geared towards manufacturing of materials and products that contain technical and product advances of others. The focal objective of these firms is to reduce manufacturing costs and use this cost advantage as a weapon to fight competition.
Process improvement has a **very strong positive impact** on product market outcomes. Strong dynamic capabilities backed by a rich web of enablers allow firms in rubber and plastics product industry in advanced sector countries to not only produce enhanced and novel products, but also improve on production efficiency. Moreover, strong institutional collaborations and high technical and scientific skills create a translational impact across processes as well as products, whereby a strong process capability enables amplification of the leverage and benefit of product-market innovations.	Process improvement **does not impact** on product market outcomes. Malaysian firms in the rubber and plastics product industry focus on their existing portfolio of products due to a lack of process improvement that enables product innovations. Firms in the industry are very reliant on price competitiveness for market success.

5.8 Summary: Key Trends, Challenges, Way Forward and Best Practices

5.8.1 Industry Trends

The industry recognises the importance of having a strong foundation of knowledge resources to remain globally competitive. The dynamic capability of firms, although lagging in components parts in comparison to the rest of Malaysia, makes positive progress in continuous improvement of its operations and manufacturing processes. The industry possesses a higher than aggregate level of adaptive capability, through which, even with a lower level of absorptive capability, is still able to respond o external changes in the environment by using its existing knowledge and technological capability. This has allowed the industry to adjust and improve its manufacturing processes and products to meet changing customer needs and to remain globally competitive. However, the results suggest that if improvements are made in its absorptive capability, notably through acquiring new customer insights and implementing systematic information gathering and sharing protocol, the industry's ability to respond to the market shifts will improve substantially.

A reason for the lack of new products to the market or to the firm (as depicted in Figure 5.9) may be because the majority of the firms in the industry are Defenders and Reactors, whose main focus rests on operational improvements and not new product development. This result is not surprising given the OEM-centricity of most firms in the rubber and plastics products manufacturing. The concern of most manufacturers is to derive improvement in manufacturing processes to cut the cost of production, rather than to invest in the development of new and innovative designs and products.

5.8.2 Challenges

While the rubber and plastics industry have undergone major structural transformations globally and they have become an important industry for many of the other industries, the local industry is experiencing a number of challenges that hurt its move up the innovation and knowledge value chain. The key challenges are discussed below.

Institutions:

- Cooperation and collaboration between stakeholders of the industry is patchy and weak.

- Lack of over-arching leadership and defined strategic direction(s) in existing partnerships and collaborations between firms, associations and universities leads to disconnects within the supply chain of the industry; hence, the industry has not been able to prioritise key strategic focus areas that will power next generation industries.

Basic Skills Development:

- Labour intensive and heavily dependent on foreign labour. Most workers are on a transitory employment arrangement and this leads to the minimal accumulation of experiential knowledge over time as workers are constantly replaced.
- Inability to attract local labour due to both due to poor working conditions and remuneration.
- SMEs have limited financial resources to train and skill up employees. Even larger firms exhibit reluctance to train workers due to high turnover and high level of poaching of skilled staff.
- Shortage of TEVT graduates and lack of trainers to conduct training at a level and in specialist areas required by the industry.

Advanced Skills Development:

- Very few firms have staff with sufficient advanced knowledge and skills to reconfigure and apply knowledge for novel and innovative outcomes.
- Skills of local graduates do not meet the innovative needs of the industry – most S&T graduates are adept users of foreign S&T but are unable to create new game changing innovations.
- SMEs face major challenges recruiting high calibre workers – most qualified local k-workers prefer working overseas or with MNCs.
- Even when advanced and technical skills exist they are employed only to adapt products to existing demands of the market - the organisational environment of local firms do not sufficiently stress or support innovative endeavour.

S&T Knowledge:

- Shortage of skilled technical workforce.
- The industry depends on "importing"/buying new and innovative technology from other countries instead of innovating knowledge locally.
- Minimal investment and resources towards R&D activities at the firm level to support sustained approach to innovation.
- Lack of strategically directed R&D activities within the industry to encourage technological breakthroughs in both natural and synthetic rubber, as well as bio-degradable plastics.
- Lack of long term strategic initiatives to lead the industry towards the notion of 'sustainability' within the rubber and plastics industry.

Market Intelligence:

- Low use of ICT, especially in SMEs, leads to failure to access information that is strategic to the development of the firms and the industry.
- Declining supply of natural rubber as raw material constrains ability to produce high value add for premium markets. Despite once holding leadership position Malaysian firms now have to source from overseas. This has created a reliance on overseas suppliers for supply, instead of replanting to assure reliable supply of high quality raw materials as a feed for high value add conversion.
- Reliance on foreign OEMs for source materials, machinery and technology constrains the firms' ability to be first movers in significant market innovations since local firms are constantly dependent on others to "feed" knowledge to them. This creates difficultly in establishing market leadership.

Knowledge Culture:

- Networking among the key stakeholders within and external to the industry is weak. Rules of engagement on IP and NDAs are in place but implementation is a problem. Resulting low trust creates a highly "protective" approach and low knowledge sharing.
- Short term outlook of firms at the expense of long term view of the industry limits ability to create collective vision in which collaboration in select areas features as much as competition.
- Weak inter-linkages with local universities and research institutions limit the virtuous cycle of knowledge creation. Some inter-lins are observed with foreign research institutions but they are ad hoc and limited due to the high costs involved. Little knowledge transfer takes place.

5.8.3 Way Forward

This industry is under intense pressure from a number of directions, which include external competition, low stock of talent and lack of continuous supply of high grade rubber to support down-stream industries. Consequently, the industry continues to operate at the lower end of the knowledge value chain. A majority of the firms are *Defenders or Reactors*, while *Prospectors and Analysers* firms make up a smaller segment of the sample firms. A majority of firms will not be able to continue to operate at the low end of the value chain over a longer time-horizon, especially in a more open regional and global economic environment. Hence, survival of this industry will depend on enhancing the enabling environment and dynamic capability of the industry so as to move local firms up the knowledge value chain. Key success factors will be for local firms to be innovative and develop new products and become suppliers for higher value-added downstream industries both domestically and globally. To move up the innovation value chain, a number of actions should be considered and are discussed below.

Recommendation 5.1: Establish an Oversight Champion to Work towards Coordinated Collective Vision and Development

- Formation of an oversight champion to address the needs of the collective development of stakeholders, including those of other complementary industries.
- Increase coordination and collaboration between trade associations, government agencies, and universities to drive change in the industry.
- Align agendas and dovetail priorities and developments to create strategically coordinated actions.
- Develop a Sustainable Natural Rubber Action Plan, and Sustainable Plastics Economy Plan to create a positive circular economy.

Recommendation 5.2: Develop a Holistic Rubber and Plastics Ecosystem

- Development of an ecosystem such that it involves the entire supply chain (upstream and downstream) of the industry to ensure continuous support in terms of resources, sharing of best practises, talents and skills.
- Integrated ecosystem approach will encourage and attract greater R&D initiatives, innovation and development of new product and technology within the industry.

Recommendation 5.3: Nurture Talent in Diverse Range and Specialist Areas Needed for the Future of the Industry: Biotech, Nanotechnology and Material Sciences

- Strengthen current undergraduate and graduate studies and programmes in agricultural sciences, materials engineering, biotechnology, nanotechnology, etc. within universities, colleges, schools to ensure specific skills are developed overtime to transform the industry into a high value add industry.
- Identification of specific universities to focus on industry specific research needs and undertake both fundamental and translational research in the rubber and plastic industry. Selected universities should work in conjunction and collaboratively with Plastics & Rubber Institute Malaysia (PRIM), Rubber Research Institute of Malaysia (RRIM), Tun Abdul Razak Research Centre to ensure knowledge development is aligned with future needs of industry.

- Provide industrial training, apprenticeship and internship opportunities with leading firms both globally and locally to ensure that prospective employees are "work-ready."

- Increase scholarship programmes in Specialised areas required by the industry to meet future skills, knowledge and talent needs. The spread of scholarships should ensure the right distribution of breadth and depth of skills is available for the industry; from technical and vocational skills to post-doctoral researchers with advanced specialisms.

Recommendation 5.4: Support Scale-Up of Operations and Capability

- Foster continuous learning opportunities for SMEs through affordable training programs and courses via universities, colleges, polytechnics, training institutes etc. This will also require ensuring the trainers with appropriate skills and knowledge are locally available to allow scale-up.

- Increase fiscal (R&D Grants, subsidies and tax exemptions) and non-fiscal incentives (access to R&D and testing facilities) to facilitate growth, based on capability building stage screening.

- Establish a strong industry network with shared collective vision of overall development so as to enable set-up of shared facility or centres to support firms in area such as fabrications, machinery, die & mould and other Specialised needs within the supply chain. Sharing of resources will help create positive spill-overs in cross-cutting capabilities that firms can use to benefit each other in a mutually symbiotic manner.

Recommendation 5.5: Buy Local First and Become Known as Global Leaders in Specific Domains

- Introduce "Buy Malaysia" or "Made in Malaysia" campaigns to encourage consumers or investors to invest in and purchase locally made products to establish strong foothold in the domestic market and build sufficient competitive strength to launch into the regional and global market.

- Identify local innovative companies who are able to take leadership positions through the development of patents and products in specific niche area(s) – provide them access to R&D funding, technological infrastructure, expertise, networks and other support systems to extend their market share in the region and globally .

5.8.4 Best Practices

Availability of natural resources and supportive government policies are among the factors fostering the growth of the rubber and plastics product industries in Malaysia. To remain competitive in these industries, the following best practices are proposed.

Best Practice 5.1: Establish an Oversight Champion to Work toward Coordinated Collective Vision and Development

UK- British Plastics Federation, University-Industry Partnerships for Success.

- Longest established Trade Federation in the world- represents 75% of industry with 400 direct members and 1600 affiliates, and 140,000+ employees, covers materials, machinery and processors.

- The federation is leading the way in understanding what sustainability means for the industrial material and continue to make strong investment in the plastics industry, especially to support frontier R&D activities in bio-based plastics, natural bio-based polymers and synthetic bio-based polymers (http://www.bpf.co.uk/).

- Industry is served by several excellent centres of excellence in Belfast, Bradford, Queens, Loughborough, London Metropolitan, and Naiper, Edinburgh that lead innovation for the industry.

- Many of the industry work closely with the world-class UK design industry and examples of leading-edge innovations include: Plastic Blood (University of Sheffield), Innovative dissolving textiles (University of Ulster and Sheffield Polymer Centre), Gloves enabling wearers to climb walls (with University of California).

- The plastics industry is the backbone for the aircraft industry, forming the base for such planes as the A380 (22% carbon fibre) and Boeing 787 (40% plastic composite fuselage), which result in savings in fuel and ultimately is better for environment.

Best Practice 5.2: Develop a Holistic Rubber and Plastics Ecosystem

Ireland – Applied Polymer Technology, Ireland Technology Gateway Programme

- Ireland Technology Gateway network provides Irish companies near to market solutions in a wide range of areas; and one of the areas is in applied polymer technology. Innovations in applied polymer technology provide solutions for a wide range of industries such as medicine, recycling, pharmaceuticals, automotive, packaging, construction and composite materials. Among the support provided by this network includes the following:

- Offers firms, both local and nationally, access to world class R&D infrastructure, expertise and resources.

- Provide firms access to technological expertise to generate solutions for market needs of the industry.

- Helps establish partnerships between research institutes and firms to facilitate technology transfer encourage applied research and develop technical expertise.

- Works closely with Plastics Ireland to help industry gain access to raw materials, services, equipment and processors for firms in Ireland.

- Link with key institutions that provide facilities for incubation for knowledge intensive firms and start-ups.

- Work closely with the industry to ensure that skills training program administered meet the needs of the industry, including facilitation of certification and development activities.

Best Practice 5.3: Nurture Talent in Diverse Range and Specialist Areas Needed for the Future of the Industry: Biotech, Nanotechnology and Material Sciences

Thailand – Developing the Bio-plastics Industry Niche

- The country set an aspiration to be the global hub for bio-plastics industry. Thereafter, institutions worked together to play an active and coordinated role in promoting and advocating for bio-plastics initiatives.

- Established key agencies, fostering key collaborations and partnerships between institutions, associations, universities and industry wide network to develop the industry.

- Reduced cost of raw materials: offered tax incentives for R&D, reduced import duties for materials not available in Thailand as part of their initiatives to enhance and attract development of the plastic industry.

- Promoted and supported development and launch of local bio-plastics products to attract local consumers as the first step in establishing competitive advantage.

- Focused on accelerating technology development through creating a cooperative blend of adopted international technologies with domestic innovation.

Best Practice 5.4: Support Scale-Up Operations and Capability

European Union – Modernisation of Vocational Education and Training (VET)

- Revised its general and vocational education to encourage specialised skills and knowledge for the future workforce in rubber and plastics industry.

- Training and lifelong learning is in place for firms in the industry and this is widely benefitted by SMEs.

- Support and upgrade the industry by providing benchmarks and best practise solutions that are open and accessible to education and training providers as well as firms.

- Improved information provision on current and future skills and knowledge needs as well as job requirements. This is essential for effective training and educational provision.

- Increase trans-sectoral and transnational mobility to promote international and inter-sectoral acknowledgement of certificates and training courses, including work mobility programmes to encourage skills development.

- Higher focus and attention given to interdisciplinary and multidisciplinary skills and knowledge.

Best Practice 5.5: Buy 'Local First' and Become Known as Global Leaders in Specific Domains

USA – American Chemistry Council's Plastics Division

- American Chemistry Council's Plastics Division represents leading companies and is dedicated to providing innovative solutions to tomorrow's challenges through plastics.

- It is also a major promoter of local products to industries in the country and across the globe – a strong advocate to persuade government, consumers and industry to use local products first.

- Working closely with America's plastics makers, it has played a role in setting standards to improve human lives both in US and globally. For example, it was at the forefront for the development bicycle helmets, child safety seats, airbags, cell phones, microwave safe plastics and other products that use plastic resin. It was also at the forefront for developing standards for helmet, airbags and food safety; and promoting environmental friendly practices. The division also helped reduce greenhouse emissions and waste by leading "REDUCE, REUSE, RECYCLE AND RECOVER" CAPAIGNS" through outreach and education as well as providing access to recycling technology.

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CHAPTER 6

KNOWLEDGE CONTENT OF THE WOOD-BASED PRODUCTS INDUSTRY

CHAPTER 6
Knowledge Content of the Wood-based Products Industry

6.0 Introduction

The wood based industry in Malaysia is made up of three main sections: (1) sawn timber, veneer and panel products (including plywood and other reconstituted panel products); (2) mouldings and builders' joinery and carpentry (BJC) such as door/ windows and flooring board/parquet; and (3) furniture (MITI, 2015).

Around 80% of the establishments in the wood based industry in Malaysia are SMEs. Most of the larger sawmills, veneer and plywood mills, process tropical wood species and are located in East Malaysia. Large number of plywood mills (45%) and moulding mills (60%) are located in East Malaysia, whereas downstream processing such as mills for fibreboard, BJC and furniture, which mainly utilises rubber-wood, is located in West Malaysia (MITI, 2015).

The numbers in **Table 6.1** show good growth in wood-based exports from 2013 to 2014. In comparison to other wood sub-industries, Malaysian furniture industry is highly export-oriented. About 90% of its manufactured products are designated for the export market. In 2010 the timber industry contributed up to 3.7% of the GDP and 3.2% of the country's total merchandise export (Malaysian-German Chamber of Commerce and Industry, [MGCC], 2012).

Table 6.1: Exports of Key Wood Based Products in 2013 And 2014

	2013 (RM billion)	2014 (Preliminary)
Sawn logs	1.87	2.01
Sawn timber	2.51	2.66
Fireboard	1.05	1.06
Plywood	5.31	5.20
Mouldings	0.63	0.72
BJC	0.96	1.01
Furniture	5.97	6.54
Others	1.00	1.12

Source: Department of Statistics Malaysia (2015)

6.1 Key Developments and Initiatives

Encouraging Sustainable Practices

Through the efforts of the Malaysia Timber Industry Board (MTIB), RM180 million was allocated to initiate forest plantation activities from 2006 onwards with an annual planting target of 25,000 hectares. Also, reforestation initiatives are incentivised through tax exemptions for five to ten years from date of assessment.

Protective Policies The National Timber Industry Policy (2009-2020) was implemented in 2009. Key stipulations include the enforcement of Sustainable Forest Management (SFM) practices in Permanent Reserve Forests (PRFs) in accordance with the requirements of the Malaysia Criteria and Indicators for Forest Management Certification (MC&I) 2002 (National Timber Industry Policy, 2009 – 2020).

Support for Automation

Realising the importance of automation is an important step towards industry development and growth. It will also reduce the reliance on foreign workers in labour intensive industries. To encourage the move to automation and use of more advanced machines, the government announced that an automation capital allowance of 200% on the first RM4million of expenses between 2015 and 2017 is available for labour-intensive industries such as rubber products, plastics, wood, furniture and textiles industry (ETP Annual Report, 2014). This initiative is particularly helpful for small players who usually lack financial capability to automate their manufacturing processes.

Combat Illegal Logging

In recent years the country has been paying due diligence to regulate the timber industry in compliance with international laws concerning illegal logging. These unlawful practices threaten the Malaysian natural reserves and damages the international reputation of the country's related exports. In 2014, the Sarawak state authorities managed to seize around RM2.95 million in illegal logs, four times the amount reported in 2013 (The Star Online, 2014). The government followed up by freezing the issuance of new timber concession licenses and clamped down further on illegal logging and smuggling activities.

6.2 Knowledge Content

Knowledge content of the wood industry is composed of a set of knowledge enablers. Having strength in these foundation elements facilitates the process of capability building and strength in competition. Looking at the industry's performance across knowledge enabler foundations (refer to **Figure 6.1**), the wood-based industry scored highest in knowledge utilisation (0.6) but lowest in knowledge generation (0.08). Among all elements of knowledge enablers, knowledge utilisation in wood-based industry made the greatest improvement from 2003 to 2014 (from 0.32 to 0.6). Evidence over time suggests that Malaysia's wood-based industry has yet to move constructively towards the government's aim of developing a knowledge-intensive economy.

The wood industry exhibits general weakness in its knowledge foundations. From 2003 to 2014 the wood-based industry performed below Malaysian industry aggregate across almost all elements of knowledge enablers and actions, except knowledge environment and knowledge utilisation (see **Figure 6.2 to Figure 6.8**). It is important to note that the significant decline from 2003 and 2007 to 2014 was observed almost across all knowledge foundations among large local firms. This may be due to the significant drop of participants since 2003, particularly among the large local firm categories (n=23) and 2007 (n=22) to 2014 (n=4).

6.3 Knowledge Enablers

6.3.1 Human Capabilities

In terms of human capability, the wood-based industry showed significant improvement from 2003 to 2007 (0.49), but experienced a slight downturn trend by 2014 (0.38) (see **Figure 6.2**). Employers have in recent years paid less attention on developing human capability. This is particularly obvious among large local firms, whose collective score dropped sharply from 2003 (0.7) to 2014 (0.25). The score is even lower than the industry average (0.38) and local micro and SMEs (0.38).

The industry relies heavily on 'on the job' training and accumulation of knowledge through experience, rather than formal training. Fuelling this reluctance for skill enhancement and investment is the fact that a number of wood-based activities, such as logging, rely on foreign workers - big companies are reluctant to invest in these employees, most of which will eventually return to their countries within a few years. In the furniture making industry, the nature of the jobs requires woodworking skill, and this is learnt through long period of apprenticeships that by nature cannot be expedited.

Figure 6.1: Overview of Knowledge Enablers and Knowledge Actions for MYKE I, II and III

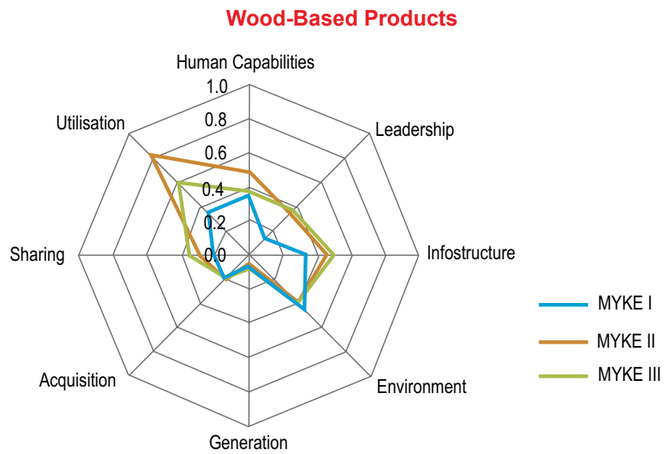


Figure 6.2: Human Capability of the Wood-based Industry

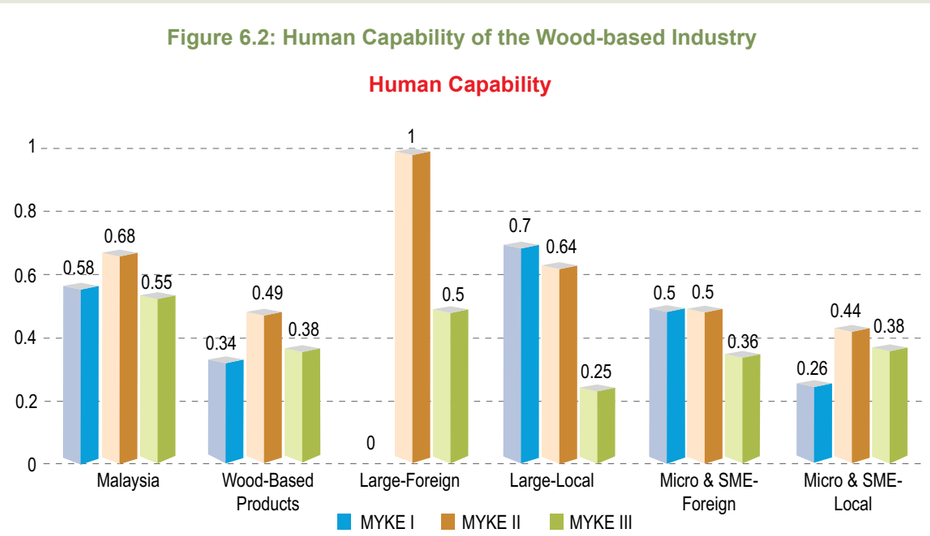
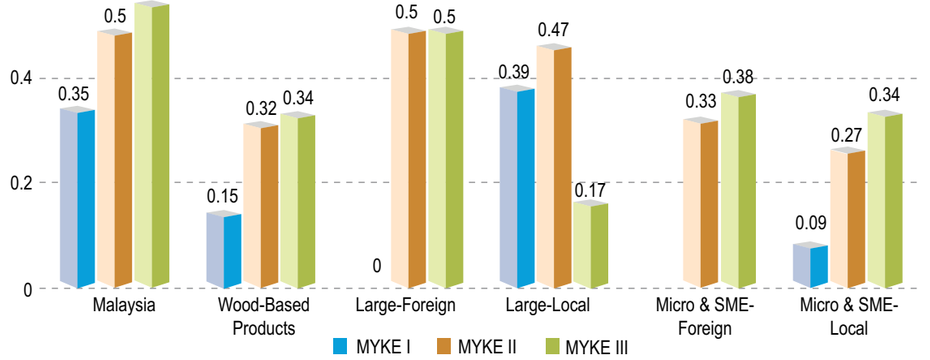


Figure 6.3: Knowledge Leadership in the Wood-based Industry



6.3.2 Knowledge Systems and Leadership

Knowledge leadership only marginally improved from 2007 (0.32) to 2013 (0.34) in the Malaysian wood-based industry (see **Figure 6.3**). It is important to note that other than large foreign firms (0.5) who are almost at par with Malaysian industry average (0.55), all other firms scored below the national industry average. This demonstrates that large foreign firms have formal mechanisms and strategies to manage and utilise knowledge and information within their organisations, and are thus much better placed to take advantage of opportunities that may arise.

A positive trend is observed among local micro and SMEs, making concerted attempt to gain ISO certification. This has been driven by global demand for higher quality products, and the smaller firms having to reach minimum certified standards by upgrading their manufacturing facilities and processes.

6.3.3 Technology and Infostructure

In terms of infostructure, the score of Malaysian wood-based industry has gradually increased from 2003 (0.34) to 2014 (0.5) (see **Figure 6.4**). Foreign firms utilise more information technologies in their operations than local firms. In 2014, both large and small foreign firms (0.61) scored higher than local large (0.32) and small firms (0.5) in infostructure. What is interesting, however, is that micro and small local firms appear to have better technological infostructure than large local firms.

6.3.4 Knowledge Environment

In terms of knowledge environment, the score among local SMEs has remained relatively stable from 2003 to 2014 (see **Figure 6.5**). SMEs continue to engage in related industry associations and actively seek information about new plans and policies over time. In contrast, large local firms score on knowledge environment dropped significantly from 0.52 in 2003 to 0.17 in 2014. Large local firms were the most actively engaged firms in 2003, but by 2014, they had become the least.

Figure 6.4: Technology and Infostructure of the Wood-based Industry

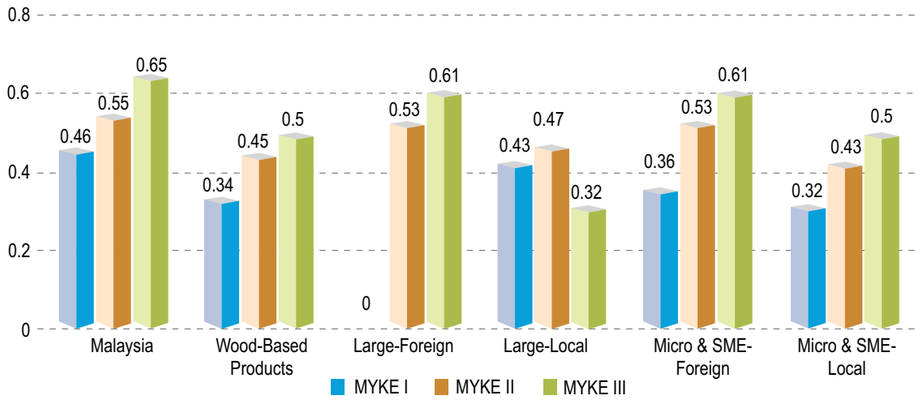
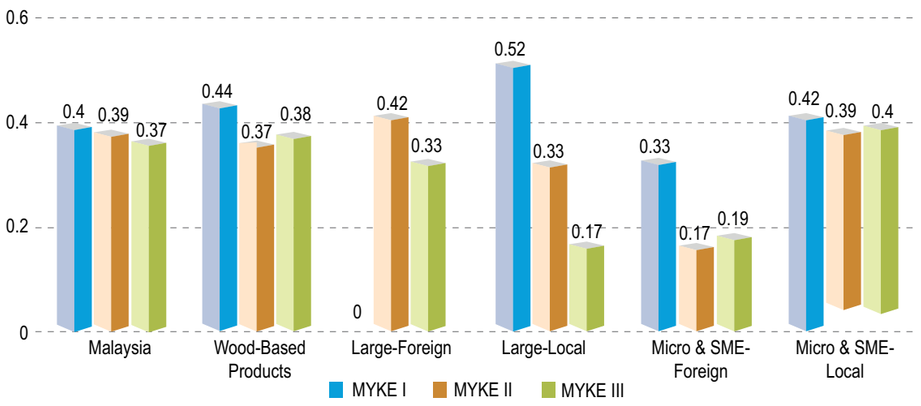


Figure 6.5: General Environment Awareness of the Wood-based Industry



Micro and SME firms tend to be the most vulnerable to changes in the macro environment, yet they possess limited personal network and resources to keep themselves updated with all of the changes at the same time. Therefore, most seek information and assistance from industry associations and government bodies to ensure survival. Larger local firms are 'self-sufficient' and less reliant on external parties, such as associations, government, university, etc. for information and knowledge.

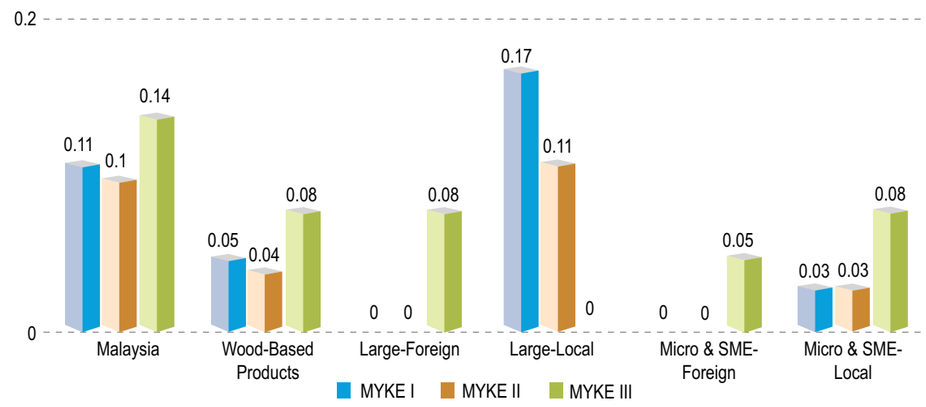
6.4 Knowledge Actions

6.4.1 Knowledge Generation

Wood-based industries score lowest in knowledge generation across all elements of knowledge-enabling foundations. There is a miniscule level of knowledge generation in terms of copyright and patent filing, as well as R&D activities (see **Figure 6.6**). All firms, even large local and foreign firms show alarmingly low levels of involvement in knowledge generation activities and R&D. For example, in furniture manufacturing, a majority of SME factories are contract mass manufacturers, producing for international brands based on designs and schematics set by their partners. Therefore, minimal internal R&D is required, and when it is done it is usually involves making minor adjustments to best suit the customers' requirements.

Additionally, large foreign firms utilise Malaysia simply as a manufacturing base, with most knowledge generation activities (such as developing new design and technologies) conducted outside the country.

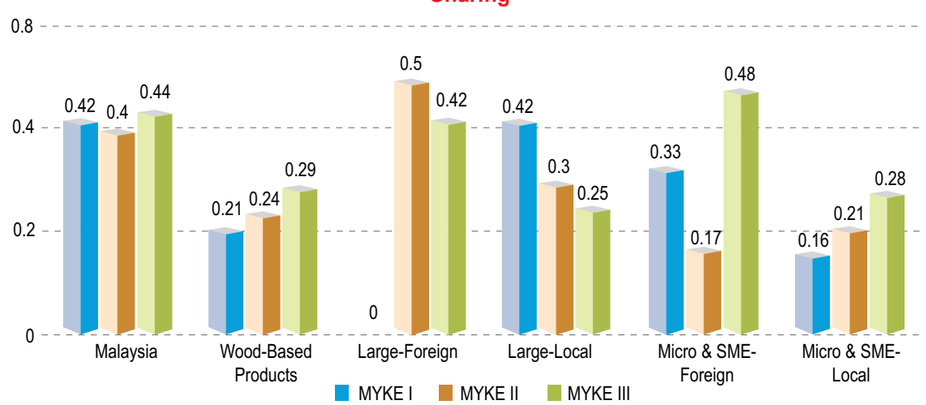
Figure 6.6: Knowledge Generation Activity in the Wood-based Industry



6.4.2 Knowledge Sharing

Overall, the score of knowledge sharing has increased marginally from 0.21 in 2003 to 0.29 in 2014, but remains well below the Malaysian industry aggregate throughout the MYKE I, II, and III periods (see **Figure 6.7**). Local firms, both large organisations and SMEs, engage in fewer knowledge sharing activities compared to foreign firms. Local firms are much more reserved in sharing information with other firms and are less formal than foreign counterparts in their approach to creating structures for sharing inside the organisation. Small local firms have shown improvement in knowledge sharing, compared to large local firms whose knowledge sharing activities have declined over time. As competitive pressures have risen, larger local firms have become more protectionist in order to retain their market share. In contrast, small companies have attempted to create more connections with a range of bodies and industry associations in the hope of finding potential collaborations or partnerships to anchor their position.

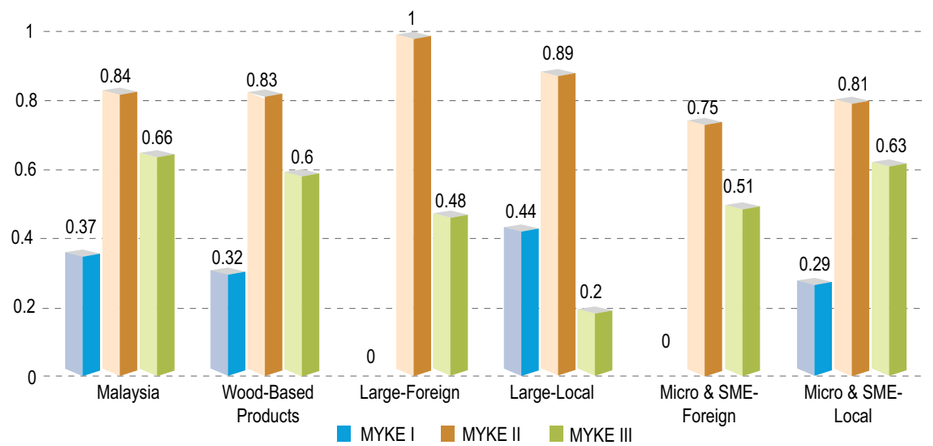
Figure 6.7: Knowledge Sharing Activity of the Wood-based Industry



6.4.3 Knowledge Utilisation

Knowledge utilisation has the highest score among all elements of knowledge enablers in the wood-based industry. Firms in the wood-based industry attempt to capitalise on whatever experiential knowledge and external knowledge they possess in their daily operation and business development. This is particularly apparent in 2007, where all firms scored 0.75 and above in knowledge utilisation (see **Figure 6.8**). However, the score decreased from 2007 to 2014 across all categories of firms.

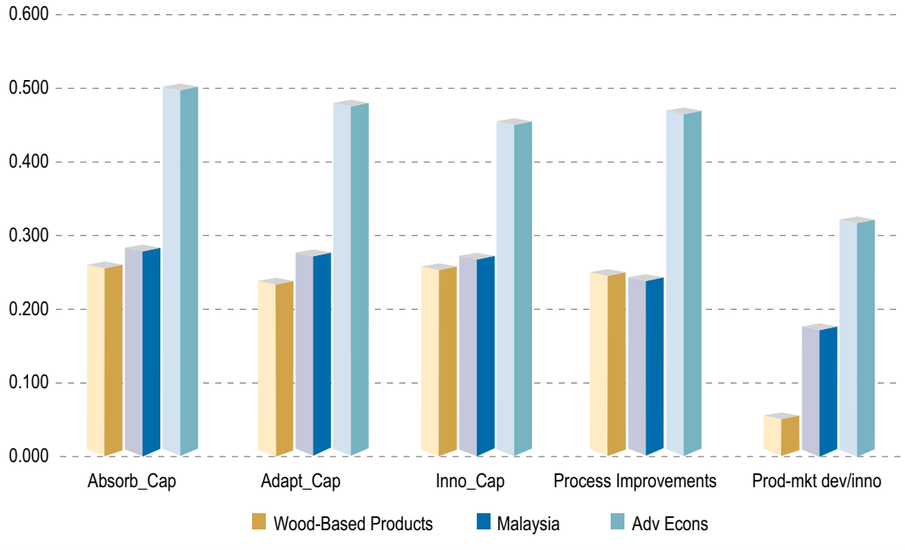
Figure 6.8: Knowledge Utilisation Activity of the Wood-based Industry



6.5 Dynamic Capabilities Profile for Wood-based Industry

The wood-based industry failed to build strong knowledge resource foundations over the years. This is evidenced by its below national aggregate scores in most knowledge enabling foundation elements. Consequently, the industry continues to struggle in building dynamic capabilities. Dynamic capabilities are constituted of absorptive capabilities, adaptive capabilities and innovative capabilities. **Figure 6.9** shows that the wood-based industry scores below national aggregate across all three components of dynamic capabilities. This weak position is also reflected by poor outcomes of product-market development, which are much lower than industry aggregate.

Figure 6.9: Dynamic Capability Profile of the Wood-based Industry



6.5.1 Absorptive Capability

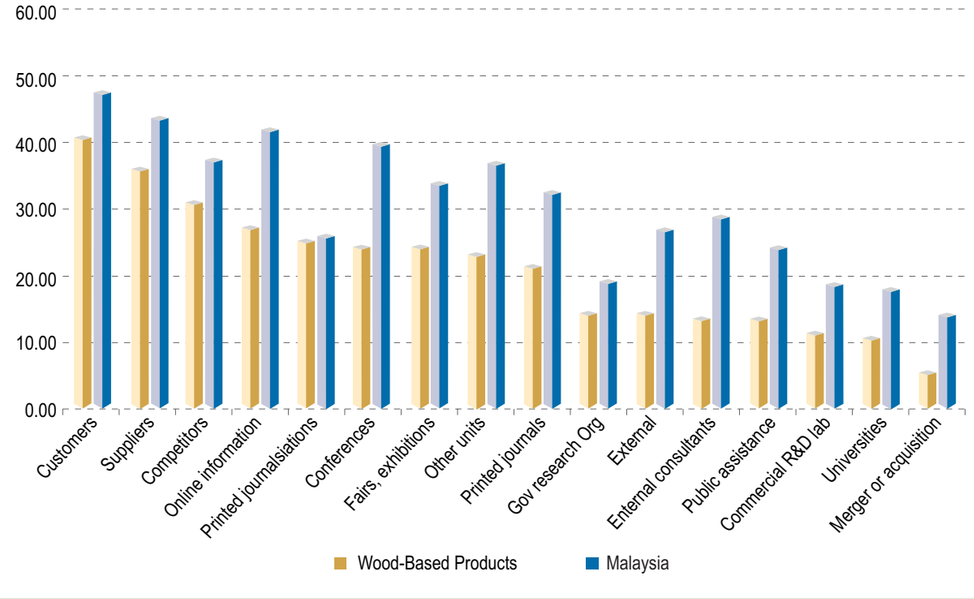
Absorptive capabilities are the first component of dynamic capabilities and refers to firm's ability to collect relevant knowledge from external sources. Firms with high absorptive capabilities are able to scan the market for new opportunities and for customers' insights. They are also able to systematically store and process this knowledge for future use. Unfortunately, firms in the wood-based industry show weakness in absorptive capabilities and score below the national aggregate. This shows that the wood- based industry's ability to absorb information and knowledge from external sources is limited. Although firms scan the market environment for new customer insights and opportunities, most are not able to systematically store and transfer learnt knowledge within the organisation.

There are many sources of knowledge that firms in the wood-based industry could utilise to develop internal capabilities. The top three sources of knowledge are customers, suppliers and knowledge from benchmarking with competitors (see F**igure 6.10**). This suggests that the wood-based industry is market focused. Having a strong reliance on suppliers and competitors also shows close linkage

of companies in the industry. Other sources of knowledge include online information, conferences, fairs, and learning from internal units. The industry also receives information from government research organisations and universities, but at a lower level.

In general, the wood-based industry access of knowledge and information is lower than the industry aggregate across all public and private sources of knowledge, and this subsequently surfaces as weakness in absorptive capability.

Figure 6.10: Sources of Knowledge in the Wood-based Industry



6.5.2 Adaptive Capability

Adaptive capabilities, the second component of dynamic capabilities, refers to firms' ability to reconfigure their resources and structures around the gathered knowledge in order to push through innovation projects and align new processes with external changes. Similar to absorptive capabilities, wood-based industry ranks low in adaptive capabilities, demonstrating the industry's inability in utilising learnt information and knowledge within firms. Firms in the wood-based industry are hesitant to invest in innovation projects and upgrade marketing capability. Accordingly, their ability to respond to emergent opportunities in a timely manner is weak.

The skill profile of firms in the wood-based industry suggests high reliance on business administration skills (see **Figure 6.11**). All the skillsets are observed to be at a lower level than the national aggregate, showing limitations in the industry's human capability profile. In addition, the overwhelming reliance on business administration skills reflects low engagement in the production of higher value-added products, which in the wood-based industry typically require more design and engineering skills.

Malaysia's institutional environment also assumes an important role in the building of industry capabilities. Among the institutions in Malaysia involved in providing assistance and support for capability building are government agencies, industry associations and universities. As shown in **Figure 6.12**, assistance to develop the market is the top priority in the wood-based industry. Other areas where wood-based firms receive help include accounting and finance, human capability development through training and skill upgrading, and the establishment of standards and process improvement. Unfortunately, the level of support received by the wood-based industry is generally much lower than the national aggregate across almost all available activities and support programmes, indicating that more can and should be done by public and private agencies to develop the sector.

6.5.3 Innovative Capability

Finally, innovative capabilities are pertinent to the ability to integrate knowledge, allocate resources and translate them into process or product-market developments. The wood-based industry scores lower than national aggregate in innovative capabilities (see Figure 6.9), demonstrating weakness in the wood-based industry's ability to leverage and integrate learnt information and knowledge within the firm for product and market development.

Malaysian wood-based industry shows low level of innovative capability building activities, as compared with Malaysian aggregate (see **Figure 6.13**). Firms in the industry place much less focus on skills upgrading, knowledge management and market intelligence. At the same time, firms' investment in R&D and design engineering is significantly below the national aggregate. It is not a surprise then that the wood-based industry has low innovative capabilities.

Figure 6.11: Skills Profile of the Wood-based Industry

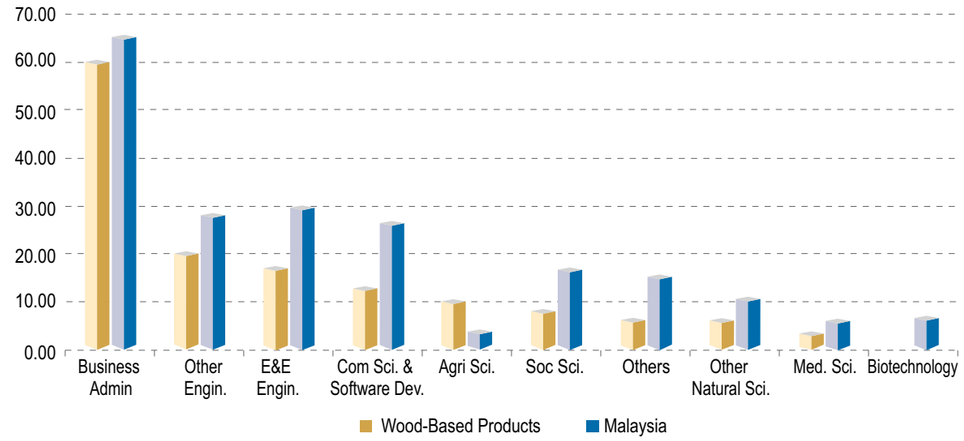


Figure 6.12: Role of Institutional Environment in Skill Building of the Wood-based Industry

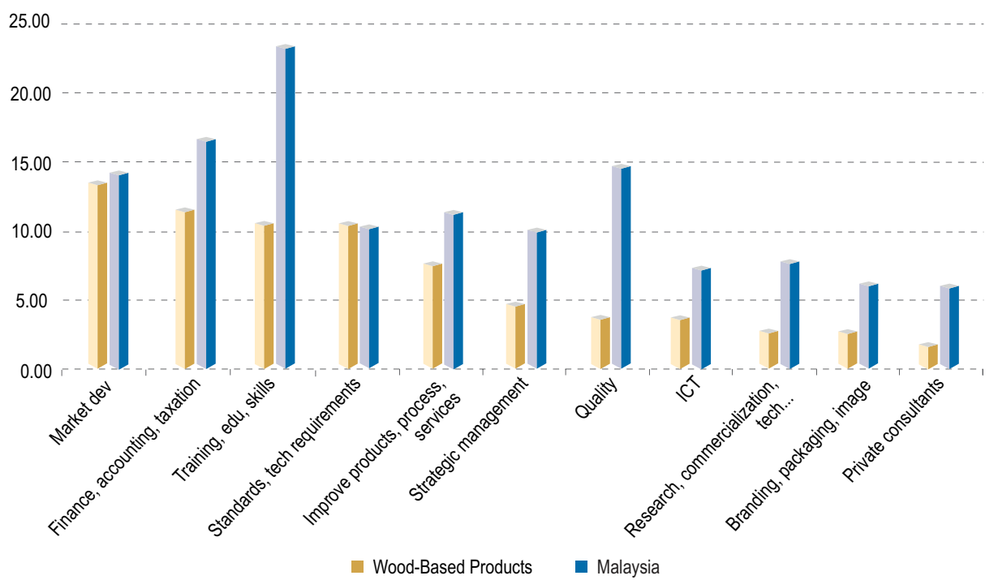
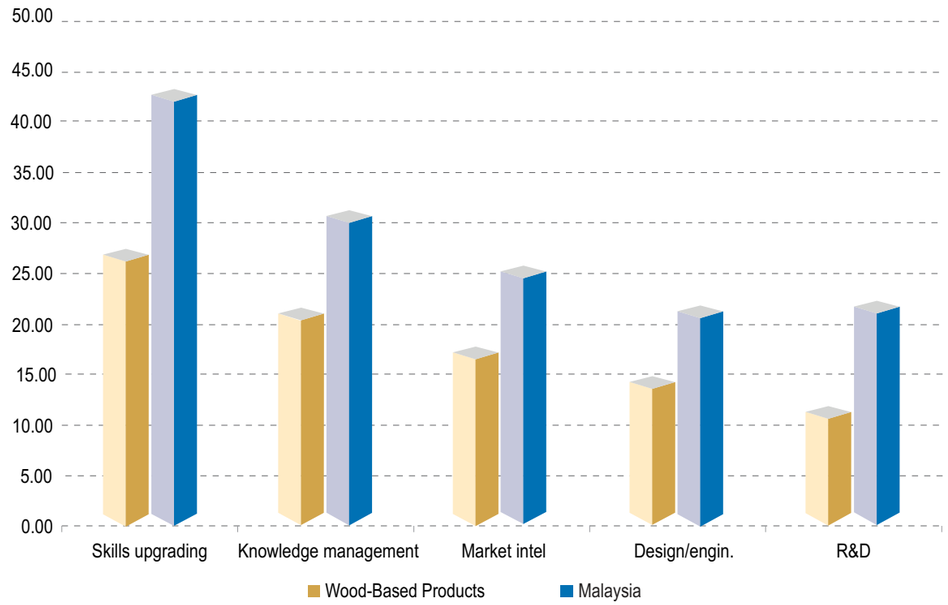


Figure 6.13: Knowledge Intensive Activities in the Wood-based Industry



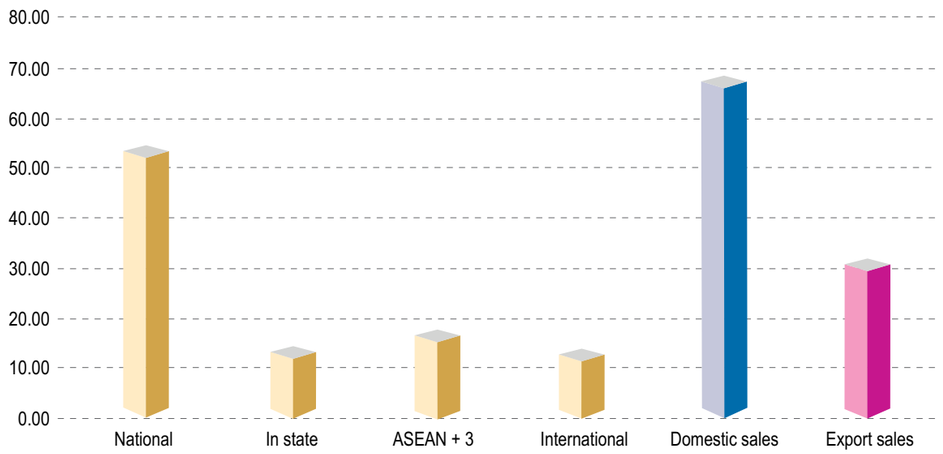
6.6 Outcomes of Dynamic Capabilities in the Wood-based Industry

The Malaysian wood-based industry has a relatively good regional and international footprint, with 31.72% of its revenue generated from export sales. This is not surprising given the popularity and demand of Malaysian timber-based products. The main share of export goes to the regional market (ASEAN plus Japan, China and South Korea) which accounts for 17.7%. The international market constitutes 14.02% of export sales. The domestic market (68.26% of sales) is state-centric. Intrastate revenues constitute 54.40% of sales in the industry, showing strong co-location. Overall, the wood-based industry reflects good presence regionally and internationally. However, the concern is that most export sales are of commodity and raw materials rather than high value-added products. The industry is yet to improve its knowledge resource foundations and capabilities to produce new and improved high value-adding products.

In terms of outcomes, interestingly, the wood-based industry has managed to improve internal processes over time. The industry performs better than anticipated and scores higher than the Malaysian industry aggregate. Much of the improvement in the wood-based industry stems from automation and standardisation of processes. To facilitate mass production for contract manufacturing of international brands, a large number of furniture manufacturers have invested in high-end technologies and machines. Many have had to invest in upgrading the manufacturing facilities in order to improve productivity and efficiency, and attain ISO certification. However, the industry remains relatively weak in its wider management and marketing processes.

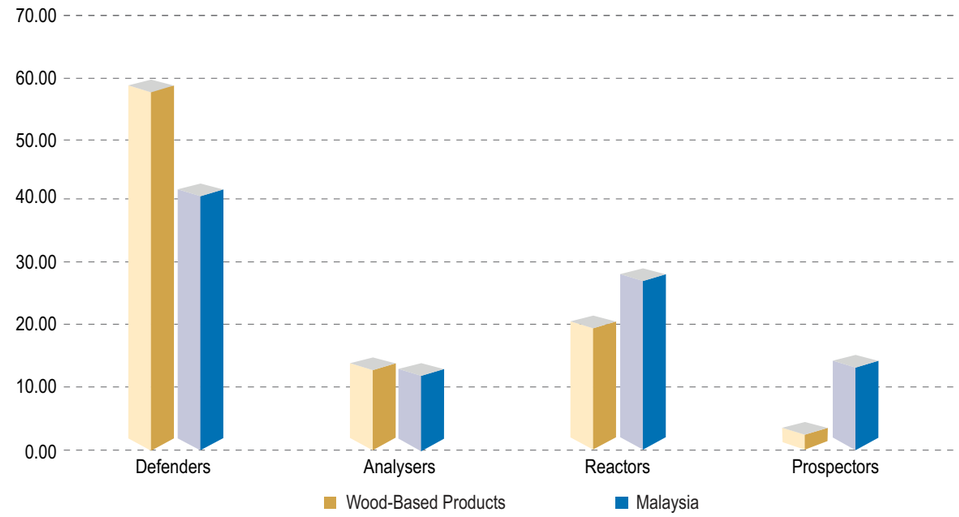
In the wood-based industry there is very little product development that is new-to-firm or new-to-market. This is not surprising given that most firms are contract manufacturers who receive design blueprints and specifications from the foreign customers, giving them little room to do brand or design development.

Figure 6.14: Market Presence of the Wood-based Industry



Note: The results are based on survey data.

Figure 6.15: Strategic Profile of Firms in the Wood-based Industry



The industry's strategic profile shows an overwhelming presence of Defender type companies (59.8%). The second largest group comprises the Reactor firms (21.57%). Both Defender companies and Reactors make up more than 80% of the industry. These firms are not innovation-driven; Defenders aim to maintain their position not by innovating but by out-competing others through price or quality, and Reactor firms are backward-looking companies that are slow to change, and do so under critical circumstances only to ensure business continuity. Defenders feature at a much higher level than the Malaysian aggregate, whereas Reactors are lower. The third group, Analysers, make up 14.71% of the firms in the industry, but the real innovators are the Prospectors. Prospector firms are willing to take risks by investing into potentially high pay-off products or services of the future. Unfortunately, the wood-based industry has very low percentage of Prospectors (3.92%), a figure that is much lower than the national aggregate.

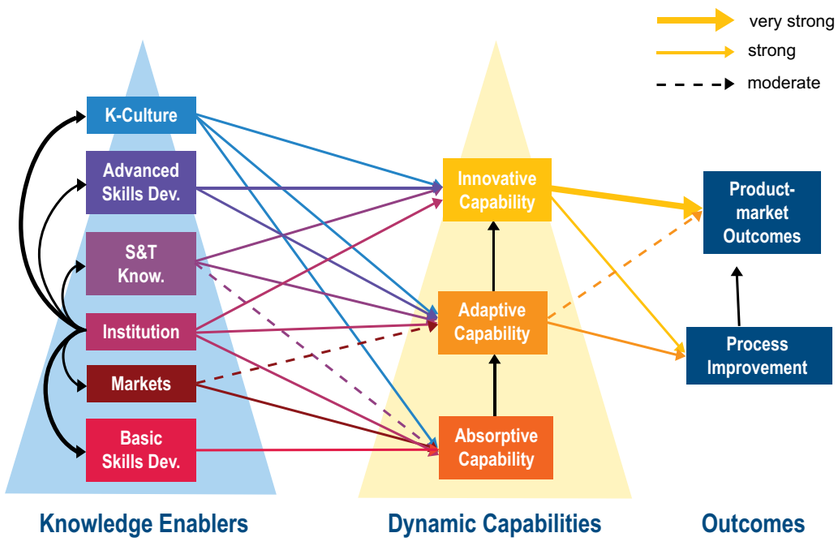
The wood-based industry is dominated by firms that focus on maintaining their market share rather than search for new opportunities (Defenders) and those who fail to anticipate or influence change in the marketplace (Reactors). This reflects the industry's low innovative capability and its poor ability to generate new products.

6.7 Relationships between the Key Blueprints of the Wood-based Knowledge Ecosystem

This section discusses the relationship between knowledge enablers, dynamic capabilities, and economic outcomes for the wood-based industry. In particular, the Malaysian wood-based knowledge ecosystem is benchmarked against their counterparts in advanced countries (Australia, Canada, Netherlands and United States). Content analysis of data and market reports for wood-based industry in advanced countries and the data obtained from DOS for the Malaysian wood-based industry indicate that the Malaysian wood-based industry is a laggard industry in terms of its knowledge content.

Figure 6.16 depicts the knowledge ecosystem for the wood-based industry in advanced countries. From this figure, it is observed that the enablers for all three components of dynamic capability are very strong. The strong absorbability capability in this industry for advanced countries indicates a solid foundation for the development of its adaptive and innovative capabilities. Sound absorptive, adaptive, and innovative capabilities enable the wood-based industry in advanced countries to develop new process improvements and generate new product outcomes.

Figure 6.16: Knowledge Ecosystem of the Wood-based Industry in an Advanced Country



Note: Very strong impacts are represented by the bolded line, strong impacts are represented by normal lines and moderate impacts are represented by dotted lines.

Figure 6.17: Knowledge Ecosystem of Wood-based Industry in Malaysia

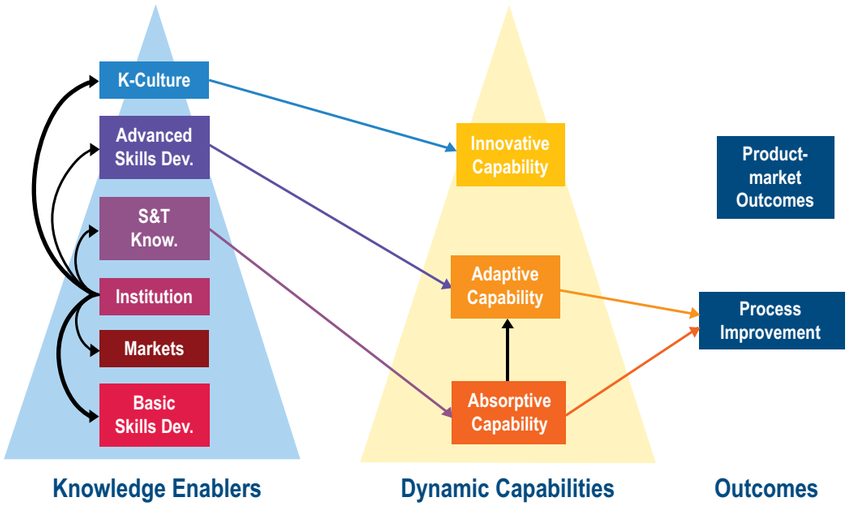


Figure 6.17 presents the knowledge ecosystem for the wood-based industry in Malaysia – a laggard industry with low knowledge content. More specifically, this figure shows that the enablers to support the three components of dynamic capability are relatively weak, and are mainly channelled toward process improvement. **Table 6.2** provides a summary of the relationships between knowledge enablers and dynamic capabilities for the wood-based ecosystems in advanced countries and in Malaysia.

Table 6.2: Knowledge Enablers and Dynamic Capabilities for the Wood-based Industry

Advanced Countries	Malaysia
Basic skills have a **positive and strong impact** on absorptive capability. The wood-based industry is an important source of revenue in advanced countries. Significant resources are provided to provide wood-based product manufacturers to continuously improve their basic knowledge through education from community colleges, technical colleges, polytechnics, and universities. The wood-based industry is reasonably technology and knowledge intensive and undergoes continuous development. Regular trainings are conducted to ensure wood-based manufacturers are kept abreast with the latest knowledge to use and operate the most advanced technology to produce high quality wood-based products, and thus become highly productive and globally competitive.	Basic skills have **no significant impact** on any of the components of dynamic capability. The wood-based industry in Malaysia is labour intensive and highly dependent on foreign labour from neighbouring countries with little resources invested on training for these workers. The competitiveness of the wood-based industry in Malaysia hinges on cheap labour cost.
Market intelligence has a **positive and strong impact** on absorptive capability and a **positive and moderate impact** on adaptive capability. Stakeholders in the marketplace, such as suppliers, customers, competitors, external consultants, R&D centres, arts and craft colleges, and logistic providers, are key drivers to enhancing absorption and adaptation of new knowledge, technology, systems and processes. This, in turn, contributes to productivity and efficiency for both upstream and downstream players in the wood-based industry in advanced countries. There is significant investment in R&D by both public and private institutions among wood-based manufacturers. This helps to keep them abreast of market conditions, new technology, innovations, and scientific discoveries that will enhance their productivity and efficiency and ability to create unique and highly sought after wood based end products.	Market intelligence **has no significant impact** on any of the components of dynamic capability. The interactions among key stakeholders in the wood-based industry in Malaysia are patchy and fragmented. Most often, partnerships are dominated by monopolistic behaviour that perpetuate 'lock-in' effect that prevents wood-based manufacturers from getting the best technology, knowledge, or innovations. Moreover, the use of ICT and new technology is relatively low and the industry is plagued by intermediaries and 'rent-seeking' behaviour.
Institutions are **strong enablers** of the knowledge ecosystem and have **direct strong and positive impact** on all three components of dynamic capability.	Institutions have a **strong impact on the enablers,** but **does not have any direct impact** on all three components of dynamic capability.

Table 6.2: Knowledge Enablers and Dynamic Capabilities for the Wood-based Industry (cont'd)

Advanced Countries	Malaysia
The federal, state, and local governments in many advanced countries make effort to ensure that the wood-based industry is well connected to other key institutions that directly and indirectly enhance productivity, efficiency, and market reach of wood-based manufacturers. Many incentives (fiscal and non-fiscal) are provided to government research institutions (GRI), colleges and universities, regulators, and trade associations to play a key role in shaping the wood-based ecosystem and directly influencing the components of dynamic capabilities in this ecosystem.	Key institutions, such as regulators, trade association, universities, and government agencies have important roles to ensure that the wood-based ecosystem in Malaysia is well developed. However, these institutions do not significantly realise any impact on the components of dynamic capability. This may be due to a number of reasons, such as the absence of a centre of excellence to conduct research and produce new innovations for the wood-based industry, poor accessibility to new knowledge and technology encountered by wood-based manufacturers, poor quantity and quantity of local talent pool due to lack of appreciation of the arts and craft-based skills and unfavourable perceptions of working in the wood-based industry. These create gaps in the integration between upstream and downstream players in the wood-based industry.
S&T knowledge has a **positive and moderate impact** on absorptive capability, but a positive and strong impact on adaptive and innovative capabilities. Basic and applied R&D activities in agricultural science and wood-based related areas are very strong in advanced countries. There is strong focus on key strategic areas needed to enhance the productivity of both upstream and downstream parts of the wood-based industry in these countries. Significant resources are also invested to help the wood-based industry in these countries to become globally competitive, such as continuous upgrading of technological infrastructure and arts and crafts colleges, research centres. There is collaboration in the market between artists, scholar and research community with wood-based manufacturers. These close relationships are an impetus forand source of new ides to penetrate the market and help both SMEs and established players to increase their global reach and competitiveness.	S&T knowledge has a **positive and strong impact** on absorptive capability. Arts and applied R&D activities in the wood-based related areas are weak in the Malaysia as compared to advanced countries. More specifically, there is a lack of talent pool for conducting high quality research and developing innovative solutions to enhance the productivity and competitiveness of wood-based manufacturers. Weak industry-university links mean most wood-based manufacturers have to rely on foreign technology, arts and aesthetics and know-how to create value for wood-based products. Compounding this problem is the fact that most firms in this industry do not have adequate financial resources to sufficiently adapt and modify existing technology. Being risk adverse, many wood based players prefer to cater to established aesthetics and technology in the development of their end product for the marketplace.

Table 6.2: Knowledge Enablers and Dynamic Capabilities for the Wood-based Industry (cont'd)

Advanced Countries	Malaysia
Advanced skills have **a positive and strong impact** on both innovative and adaptive capabilities. Significant resources are invested to strengthen research, artisanship and business processes (e.g. production, marketing, accounting) to support firms in the wood-based industry in advanced countries. Such investments are also seen in educational wood-based courses. The presence of strong partnerships between stakeholders in the wood-based industry allows wood-based manufacturers to leverage seamless facilitation of knowledge to close the 'knowledge-commercialisation gap' and to improve their adaptive and innovative capabilities.	Advanced skills have **a positive and significant impact** on adaptive capability. Despite the significant resources invested to improve advanced skills and capabilities, the talent pool produced in Malaysia remains one whereby individuals in the sector simply adapt existing knowledge and processes. Very few local wood-based manufacturers undertake cutting-edge R&D, create advances in aesthetic design or initiate innovative endeavours in key areas of specialisation to significantly advance the Malaysian wood-based industry. The best Malaysian talent tend to be employed in other more "attractive sectors" especially by foreign MNCs. Many talented individuals migrate to more advanced countries where the opportunities and career prospects are much better. The lack of highly specialised skills combined with brain drain hinders the translation of advanced skills into innovative capabilities for the Malaysian wood-based industry.
Knowledge culture has a **positive and strong impact** on all three components of dynamic capability. Industry-relevant knowledge competency and art and design literacy among wood-based manufacturers is high in advanced countries. Most wood-based manufacturers are well informed about market developments and innovations taking place domestically and globally. They absorb information from a wide range of sources, as well as market data from government agencies and trade associations. This is then internally used to tease out the necessary adaptations and innovations. New start-up companies come into the sector on the basis of specialist knowledge that can value-add to existing market space.	Knowledge culture has **a negative impact** on innovative capability. Industry-relevant knowledge competency and design and arts skills rare relatively weak among wood-based manufacturers in Malaysia, compared to advanced countries. A culture of dependency on the developed world for art and design knowledge as well as science and technology prevails widely in the industry. Most wood-based manufacturers are reluctant to undertake new innovations and creative ways to enhance productivity and market opportunities. Instead they rely on existing and foreign knowledge and technology in their operations and manufacturing processes.

Table 6.2: Knowledge Enablers and Dynamic Capabilities for the Wood-based Industry (cont'd)

Advanced Countries	Malaysia
	Moreover, market failures, such as monopolistic and oligopolistic behaviour perpetuated by intermediaries, tend to lead to wide spread rent-seeking behaviour and hinder sharing of best practices or ideas across the industry. In turn, this creates a lack of trust in employees and high staff turn-over of talented staff. Talented individuals often to migrate to countries where there is greater recognition for their specialised skills and rewards commensurate to their contribution to the firm and industry.
The continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** Significant resources are channelled to encourage and support leading centres of excellence. These help wood-based manufacturers to continue to make design, artistic and technological breakthroughs to raise the quality and quantity of wood-based products. Additionally, most advanced countries wood based companies adhere to global environmental standards and best practices in order to ensure the long-term sustainability and competitiveness of the wood-based industry.	The continuum from absorptive capability to adaptive capability to innovative capability **is present.** Despite significant investments to increase the quality and quantity of the talent pool for the wood-based industry, the wood-based industry in Malaysia struggles to get the right calibre of employees as compared to those in advanced countries. This is particularly the case for the higher end advanced skills needed in innovative production and application of wood-based products. Local talent is able to absorb and adapt at the basic level existing and foreign knowledge and technology in developing wood-based products.

Table 6.3 summarises the impact of dynamic capabilities on economic outcomes for the wood-based industry in advanced countries and in Malaysia. In advanced countries, adaptive capability is found to have a positive and strong impact on process improvements, and a positive and moderate impact on product market outcomes. Besides that, innovative capability is found to have a positive and strong impact on process improvement and product-market outcomes. These findings suggest that the wood-based industries (both upstream and downstream parts of the industry) in advanced countries are able to generate strong level of process improvement and new market outcomes.

In contrast, the absorptive and adaptive capabilities of wood-based manufacturers in Malaysia are found to have a strong and positive impact on process improvement only. Innovative capability does not have any significant impact on process improvement or new product-market outcomes. The difference arises from Malaysian wood-based industry's heavy reliance on cheap foreign labour and its strong proclivity to the simple adoption of foreign technology and innovations to improve systems and processes to remain cost competitive.

Table 6.3: Dynamic Capabilities and Economic Outcomes for the Wood-based Industry

Advanced Countries	Malaysia
Adaptive capability has a **positive and strong impact** on process improvement and a **positive and moderate impact** on product-market outcomes. Most SMEs in the wood-based industry in advanced countries are very strong in adapting new technology and innovations to improve existing products and services. Most often, these SME wood-based manufacturers supply products and services for larger MNCs in the wood-based industry. There are also another set of players (MNCs) that emerge from these countries that operate in the upstream and downstream parts of the wood-based industry in their own and other countries. These set of wood-based manufacturers often control the supply of the wood-based products and also the retail and supply networks for these products, thereby giving them greater opportunities to pursue both economies of scale and scope at the international level.	Absorptive and adaptive capabilities have **positive and strong impact** on process improvement. Most wood-based manufacturers in Malaysia are labour intensive and not technological savvy. Many rely on cheap foreign labour and use foreign technology and designs to improve their processes and value-add their products. As a result, they do not produce significant high-end wood-based products.
Innovative capability has **a positive and strong impact** on process improvement and a positive and very strong impact on product-market outcomes. Significant investment in R&D and skilled workforce enables wood-based manufacturers to produce more efficiently and enhance their productivity as well as introduce new innovations and applications. Many of wood-based manufacturers, especially large MNCs, have global reach and richness in their products and services. Many of these globally minded firms compete on developing very strong brand identity to capture market share.	Innovative capability **has no significant impact** on process improvement and product-market outcomes. Most wood-based manufacturers in Malaysia adopt technology and innovations from more advanced countries to improve cost-efficiency and meet domestic market demand. The quality and quantum of innovations undertaken by manufacturers in Malaysia is relatively meagre compared to foreign counterparts in advanced countries. Thus, the innovations undertaken by wood-based manufacturers in Malaysia fail to have any significant impact on product-market development.
Process improvement have a **positive and moderate impact** on product-market outcomes. The wood-based industry in advanced countries is well developed, as firms in this industry interact with and form strong partnerships with their stakeholders. This enables them to translate process improvements into new wood-based product development that are globally competitive.	Process improvement **does not have any impact** on product-market outcomes. Process improvements undertaken by wood-based manufacturers in Malaysia are dependent on foreign technology and intellectual property. Thus, the potential of creating new wood-based products from the borrowed IPs are limited for firms in Malaysia.

6.8 Summary: Key Trends, Challenges, Way Forward and Best Practices

6.8.1 Industry Trends

The wood-based industry happens to be one of the weakest industries in terms of building knowledge resource foundations and knowledge capability. Firms in the industry consistently performed below national aggregate level across most knowledge enablers over the period of 2003 to 2014. Knowledge environment and knowledge utilisation are the only knowledge resource foundations where the industry performs on par with national aggregate. Nonetheless, the industry showed improvement in its awareness and approach to the management of knowledge, use of technology and computers. There was also signs of positive change in knowledge generation and knowledge sharing over the years. Unfortunately, the industry continues to suffer from problems in attracting human capital due to the unattractive nature of the industry and poor compensation plans. Interestingly, micro and SME firms seem to show a more solid performance than large firms.

The wood-based industry does not perform well on the dynamic capabilities factors. The industry scores below Malaysia industry aggregate across all three types of dynamic capabilities. In terms of outcomes, the wood-based industry manages to display positive improvement in internal processes despite having low dynamic capabilities but the industry performs very poorly in terms of product-market development. This is unsurprising given that most firms in the industry are heavily involved in contract manufacturing. Industry players have to take active role in improving the manufacturing process in order to remain competitive. The process improvement mainly focuses on cost-cutting and increasing efficiency level.

6.8.2 Challenges

Due to scarcity of sustainable wood sources and stricter requirement from global markets to have the manufactured products certified as sustainable resources, Malaysian wood-based manufacturers face serious challenges to grow the industry. Whilst the Malaysian Government is taking the initiative to facilitate sustainability of wood resources by promoting forest replantation, encouraging smart forestry methods, and improving the design and development of the local wood-based industry, the industry faces a number of challenges. These challenges are discussed below.

Institutions:

- Absence of Centres-of-Excellence or comparable disciplines to champion research and produce new innovations for the wood-based industries.
- Poor dissemination of knowledge limits the accessibility of new technology to manufacturers.
- Poor quality and quantity of local talent pool due to lack of appreciation of the arts and craft-based skills.
- Systemic issues mentioned above widen the gap between upstream and downstream players, limiting the amount of synergies achieved within the sector.

Basic Skills Development:

- Difficulty in attracting new labour due to unfavourable perceptions of working in the wood-based industry.
- Production remains labour-intensive as the industry is unable to progress technologically toward more efficient capabilities due to lack of appropriate talent and use of new technology.
- Prioritising of cost optimisation over business development has led to over-reliance on foreign workers.
- High turnover rate and the lack of language proficiency in new entrants makes training difficult and costly for this industry.

Advanced Skills Development:

- Workers simply adapt existing knowledge and processes - very few local firms undertake cutting-edge R&D, create advances in aesthetic design or initiate innovative endeavours in key areas of specialisation to advance the industry.
- Talented individuals tend to be employed in other more “attractive sectors” especially by foreign MNCs.
- Many talented individuals migrate to more advanced countries where the opportunities and career prospects are much better.
- Lack of highly specialised skills combined with brain drain hinders the translation of advanced skills into innovative capabilities for this sector.

S&T Knowledge:

- Arts and applied R&D activities in the wood-based related areas are weak - talent pool largely comprises operation-level workers, with few qualified to conduct high quality R&D innovative solutions to enhance the productivity and competitiveness of the manufacturers.
- Weak industry-university linkages – reliance on foreign technology and aesthetic know-how.
- Lack adequate financial resources to sufficiently adapt and modify existing technology.
- Strong risk aversion has firms preferring to cater to established aesthetics and value propositions instead of serving as a driving force for change in the marketplace.

Market Intelligence:

- Networking among the key stakeholders is patchy and fragmented.
- Widespread rent-seeking behaviour hinders sharing of best practices or ideas across the industry.
- Low use of ICT and new technology, especially SMEs; hence this hinders the firms from gaining access to valuable information and knowledge to transition from a labour intensive to a knowledge intensive industry.

Knowledge Culture:

- Industry-relevant knowledge competency. Design and arts skills are rare and relatively weak.
- Culture of dependency on the advanced world for art and design knowledge, science and technology.
- Partnerships dominated by monopolies that perpetuate supply chain ‘lock-in.’
- Most manufacturers are reluctant to undertake new innovations, instead they rely on existing and foreign knowledge and technology in their operations and manufacturing processes.
- Most SMEs run small scale operations and employ very simple or outdated technology.
- Poor human capital retention perpetuates distrust toward employees, while high staff turnover of talented staff remains unaddressed.
- Talented individuals often migrate to sectors/ countries where there is greater recognition of their specialised skills.

6.8.3 Way Forward

The development of the wood-based industry in Malaysia focuses on the value added downstream products. In recent years, this industry is affected by increasing competition from low-cost countries. To sustain continual growth of the wood-based industry in Malaysia, the following recommendations are made.

Recommendation 6.1: Sustainable Management of the Forest and Supply of Wood

- Put in place a strategic forest management plan that ensures sustainable management of local forest industry for the future generations and also ensure the industry is able to produce high quality yield and better return on investment.

- Elements of the plan should contain the following:
  - Close monitoring of timber firms and ensure they adhere to their annual quotas and pursue a replanting and regeneration programs.
  - Ensure that the timber firms adhere to regulations on protecting soil, river, ground water and lifestyle of the local communities, plant and animals in the jungles.
  - Regular audits undertaken on the practices of the local timber companies and punitive measures taken against non-compliance of regulations and standards.
  - Work closely with the research and scientific community to improve the management practices, innovative cutting methods for harvesting and replanting the forests in more cost-effective and sustainable ways.
  - Develop new applications vis-à-vis new technology to enable more accurate measurements of the inventory of trees, stages of development of the trees and illegal logging practices.

- Key players in this industry need to look for alternative materials for making wood-based products, such as rubber wood, oil palm trunks, and coconut treads.

- Policies also need to be refined to ensure that a certain percentage of high quality raw materials is retained for local manufacturing activities of finished products. This will ensure lower barriers-of-entry for small and medium players to enter the premium goods market, increase high quality and innovative products hence helping them to compete internationally.

Recommendation 6.2: Nurturing an Innovation and Design Mind-set – Industry 4.0

- Incorporate *Industry 4.0* within the wood-based industry, which will enable the production and manufacturing processes to be seamlessly integrated and automated. This will help the industry achieve economies of scale and scope, making them less reliant on foreign labour. They will also be able to produce high quality and diverse products for the domestic and international markets.

- Furniture manufacturer should incorporate innovative ways to enhance productivity using Computer Numerical Control (CNC) systems to produce high quality finished products. The CNC systems can able be used to customise furniture and wood-based products at highly competitive rates and in a relative short period of time.

- Industry players need to identify niche markets and offer differentiated products, and reinforce this by upgrading their marketing and business intelligence capability. This will enable them to move away from low-end markets and start producing premium, highly-sought after products. This will require investing in more systematic brand development, marketing and promotion strategies.

Recommendation 6.3: Develop Long Term Plan for Key Human and Technology Capabilities

- Innovation in any industry will only be successful if strategic plans are supported by a sound talent development strategy. To attract the best graduates, the industry should invest in providing scholarships, industry placements and other similar forms of support to nurture the next generation workforce for the industry. Graduates with sound engineering, design, science, arts and information technology discipline areas should be recruited to help develop some of the home-grown innovations and high value-added products for the industry. Investments should also be intensified to increase the number of TVET graduates who will be the key workforce for a technology-intensive wood-based industry.

- Greater resources should be channelled for focused R&D in advance durable composite materials that are integrated with wood-based products, which will have wider applications and spill-over impact on other industries such as the automobile, aircraft and construction industries.

Recommendation 6.4: Create Strong Awareness of Market and Technological Factors for Competitiveness

- Local firms should attend international trade fairs such as 2015 Ligna in Hanover, Germany and other international industry forums in other OECD countries that promote the incorporation of Industry4.0 for the wood-based industry. These tradeshows provide valuable information on leading R&D, technology and innovative practices used by leading wood-based manufacturers to enhance their global competitiveness. These fairs and forums also show how leading firms produce innovative products in cost-effective ways for the wide segment of the population using flexible and smart manufacturing technology. The trade shows will enable local firms to establish industrial collaborations with leading global manufacturers, enabling them to enhance their absorptive, adaptive and innovative capabilities.

6.8.4 Best Practices

In line with the nation's vision of a thriving and self-sustaining industry, efforts should be intensified towards the development of Malaysian wood-based industry in a more sustainable manner. To ensure the wood-based industry moves up the knowledge value chain, the following best practices are proposed.

Best Practice 6.1: Sustainable Management of the Forest and Supply of Wood

Forest Management Plan, Natural Resources Canada

- The Canadian Government has put in place a sustainable forest management plan to ensure the forest reserves for the next generation, and to secure a steady stream of wood supply for the industry in the future. The plan has incorporated a strict system of monitoring the timber logged, replanting programs and maintaining the optimal stock of trees available to ensure that the natural habitat is not adversely impacted.

- The Natural Resources Department has established a number of research centres across the country to study a wide range of issue such as: develop new methods of harvesting timber; technology and predictive tools for accurately mapping forest inventory; detection tools of infestations; assessing socioeconomic impact of the forest industry on communities and the economy; and evaluation of the impact of timber logging on climate change.

- Some forest and wood-based research institutes also undertake forest genomics to produce wood-fibre that has special attributes, such as infestation resistance; produce multiple variety of forestry species; fast growing trees and woody crops; generating forest biomass and woody residue that becomes a sources of supporting the Canadian bio-economy.

- The Canadian Government has introduced a certification system for forestry operators to adhere to Sustainable Forest Management (SFM) best practices. These best practices are important to meet the needs of the wood-based industry, especially in North America and Europe. This system is a source of competitive advantage to the Canadian wood-based industry.

Forestry Commission, UK

- The commission works closely with key organisations such as Programme for the Endorsement of Forest Certification (PEFC) and Forest Stewardship Council (FSC) (Forestry Commission, 2014) to ensure that the wood extracted from the forest are from legitimate sources. The key unit of the Forestry Commission also assists firms in incorporating sustainable harvesting practices and introduce replanting programmes that mitigate the impact of deforestation on the environment.

Best Practice 6.2: Nurturing an Innovation and Design Mind-set – Industry 4.0

IKEA of Sweden

- IKEA is the world's largest furniture retailer. A key strategy of the firm is to invest in their innovation strategy to ensure the products are fit for purpose and cost effective. Innovative "flat-pack" concept for delivery of furniture eases logistics & storage, lowers transport cost and also reduces customer prices. The innovative designs are achieved by the firm working closely with a wide range of stakeholders from design firms, universities and consumers.

- IKEA has established a number of *Home Innovation Incubators,* test ideas centres, prototypes and testing facilities where potential customers are invited to use the products and live in the facilities and document their experiences in using furniture and facilities. Information from these experiments is used for future product development.

- IKEA invests significant resources in building its brand identity. IKEA produces "products for a better everyday life."

- The firm is also conscious of the effects of social responsibility and invests resources and promotion materials to brand it as being an environmentally-friendly company, using renewable and recyclable materials and contribute to low CO2 emission.

- Wood based industry needs to work closely with many leading trends and innovations taking place in the market place through the efforts of firms such as IKEA.

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CHAPTER 7

KNOWLEDGE CONTENT OF THE FABRICATED METALS INDUSTRY

CHAPTER 7
Knowledge Content of the Fabricated Metals Industry

7.0 Introduction

China is the world's largest producer of steel by a huge margin, accounting for more than the combined outputs of the next four largest producing nations (Japan, US, India and South Korea). In 2014, China produced 823 million tons of steel, which accounts for half of the global output (Pham, 2016). In 2015, China's crude steel output decreased to 803.8 million tonnes (Reuters, 2016). However, the industry is of immense importance to the manufacturing bases of most economies, and doubly vital to the overall economic wellbeing of emerging countries with a manufacturing predisposition.

In Malaysia, the fabricated metals industry (commonly referred to as iron and steels industry) relies heavily on imported raw materials. In 2015, Iron and Steel products (RM21.8 billion) and Manufactures of Metals (RM44.1 billion) are both among the top ten imported products in Malaysia (Ministry of International Trade and Industry [MITI], 2016) by value. For exports, Manufactures of Metals (RM34.9 billion) is among the top ten exports of Malaysia[1]. For details, refer to **Table 7.2.**

[1]Top ten Malaysian exports in 2015 are: E&E products, chemicals and chemical products, petroleum products, LNG, palm oil and palm-based products, machinery, appliances and parts, manufacturers of metal, optical & scientific equipment, crude petroleum and rubber products (Ministry of International Trade and Industry Malaysia, 2016).

Table 7.1: Global and Malaysia's Annual Growth, Production, Demand and Consumption of Steel

Global production of steel & annual growth	1,607 mil tons; 3.5% (2013); 1,636 mil tons (estimated in 2014)
Global demand for steel	Estimated to increase by 3.1% to 1,629 mil tones (2014);
Malaysia's production of steel & growth	4.79 mil tons; 11.65% y-o-y (2013)
Malaysia's consumption of steel & growth	11.69 mil tons; 12.6% y-o-y (2013)

Source: Exim Bank Industry Assessment (2015)

Table 7.2: Imports and Exports of Manufactures of Metals (Top Five Destinations) 2014/2015

Manufactures of Metals	Country	2015 (Provisional Data)		2014	
		RM billion	Share %	RM billion	Share %
Imports	**Total**	**44,092.2**	**6.4**	**41,723.9**	**6.1**
	China	10,527.1	1.5	10,628.2	1.6
	Australia	5,488.1	0.8	7,540.3	1.1
	Japan	4,550.6	0.7	4,780.4	0.7
	Singapore	3,214.2	0.5	2,133.2	0.3
	India	3,094.3	0.5	652.1	0.1
Exports	**Total**	**34,909.1**	**4.5**	**26,443.6**	**3.5**
	China	4,619.7	0.6	3,267.9	0.4
	Singapore	4,306.2	0.6	4,417.7	0.6
	Chinese Taipei	3,689.3	0.5	1,003.4	0.1
	Australia	3,119.1	0.4	1,311.2	0.2
	India	3,027.1	0.4	2,512.0	0.3

Source: Ministry of International Trade and Industry [MITI] (2016)

Basic metal products is one of the industries with high levels of foreign investments (RM2.7 billion), after the E&E industry (RM8.2 billion) in 2015 (Ministry of International Trade and Industry [MITI], 2016).

As of 2015, Malaysia's iron and steel industry contributes about 4% to the GDP (ReportLinker, 2016). The Iron and Steel industry is a core industry in Malaysia supplying essential raw materials to manufacturing, transport equipment, construction, machinery and other industries. The industry is categorised into two segments - long products and flat products. Long products are predominantly used in the construction industry (such as billets, bars, wire rods, sections, nails, wire mesh, bolts and nuts). Flat products are mainly consumed by the manufacturing, construction, and oil and gas industries (such as hot-rolled plates and sheets, cold-rolled coils, tubes, pipes, boiler and pressure vessels).

7.1 Key Developments and Initiatives

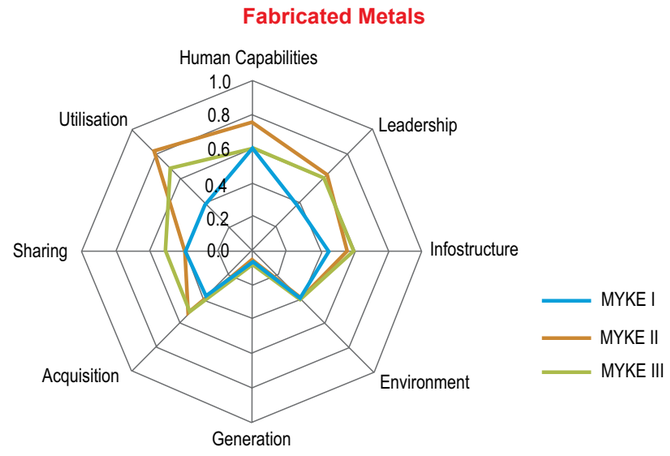
There have been two notable recent events that have had a profound impact on the fabricated materials industry in Malaysia. Firstly, the Malaysia Steel Institute (MSI) was established on 2 January 2014 and is now primarily responsible for human capital enrichment, research and development, formulation of standards and advisory services for the industry. Secondly, in 2014, Malaysia began imposing an antidumping duty on Hot Rolled Coil (HRC), Steel Concrete Reinforcing Bar (REBAR), and Hot Rolled Plate imports from key trading partners. This was to ensure the continued viability of Malaysian firms in the industry.

7.2 Knowledge Content

In 2014, almost all elements of knowledge enablers in fabricated metals industry are on par with the Malaysian industry average, indicating an average performance of the industry.

Human capabilities and knowledge utilisation progressed positively from 2003 to 2007, but dropped from 2007 to 2014. Other enablers exhibited a good level of improvement from 2003 to 2007 and then slowed down. Overall, the improvement in most knowledge elements between 2003 and 2007 was substantial but began to stagnate by 2014.

Figure 7.1: Overview of Knowledge Enablers and Knowledge Actions for MYKE I, II and III



7.3 Knowledge Enablers

7.3.1 Human Capabilities

In the fabricated metals industry, the human capability score improved from 0.59 in 2003 to 0.76 in 2007 (see **Figure 7.2**). However, this subsequently decreased to 0.59 in 2004. Despite the drop, the human capability within the industry has been consistently higher than the Malaysian aggregate, suggesting that employees in the fabricated industry receive persistent, above-average levels of training.

By 2014, large foreign firms exhibited the best performance in human capability (0.81). Compared to their counterparts, large foreign fabricators owe much of this to high investments in employee training, and a stronger capability to attract and retain qualified employees.

7.3.2 Knowledge Systems and Leadership

The score of knowledge leadership in fabricated metals industry rose rapidly from 0.38 in 2003 to 0.62 in 2007, but only marginal improvement was experienced thereafter to 2014 (see **Figure 7.3**). A similar positive trend is observed among local firms (both large and smaller firms) indicating an

Figure 7.2: Human Capability of the Fabricated Metals Industry

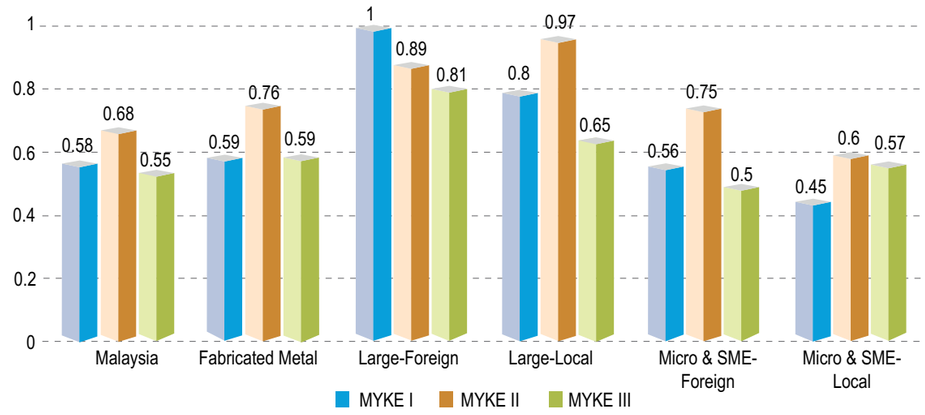
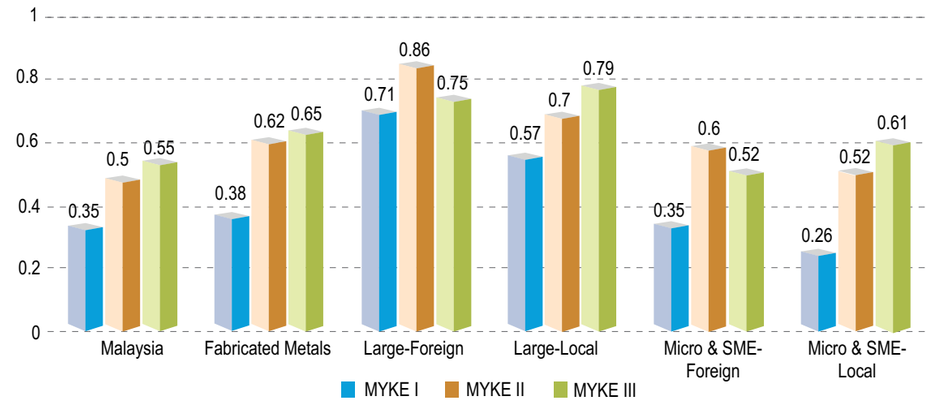


Figure 7.3: Knowledge Leadership in the Fabricated Metals Industry



improvement across the board among local firms in their ability to institute systems and processes for the management of knowledge through formal processes of ISO certification.

Foreign firms experienced strong improvement from 2003 to 2007 but a decline in performance by 2014. Local large firms have demonstrated the best performance in knowledge leadership (0.79) by 2014. Most local large firms in fabricated metals industry tend to have systematic documentation procedures to capture and document knowledge.

7.3.3 Technology and Infostructure

Infostructure in fabricated metals industry improved from 0.43 in 2003 to 0.57 in 2007, and to 0.6 in 2014, which is almost on par with the Malaysian industry average (see **Figure 7.4**). This trend is observed in all firm categories, except for foreign micro and SMEs, whose scores dropped from 0.62 in 2007 to 0.43 in 2014.

Large foreign firms and large local firms score higher in infostructure compared to smaller firms as they have deeper resource pools and extensive networks for investments into computer hardware. Large firms are also more active in e-commerce compared to their smaller peers.

7.3.4 Knowledge Environment

Firms in fabricated metals industry are reasonably engaged with the institutions supporting their knowledge building capability, with the score rising marginally from 0.35 in 2003 to 0.38 in 2007, and then declining to 0.36 in 2014 (see **Figure 7.5**). This is below the Malaysian industry average (0.37).

Figure 7.4: Technology and Infostructure of the Fabricated Metals Industry

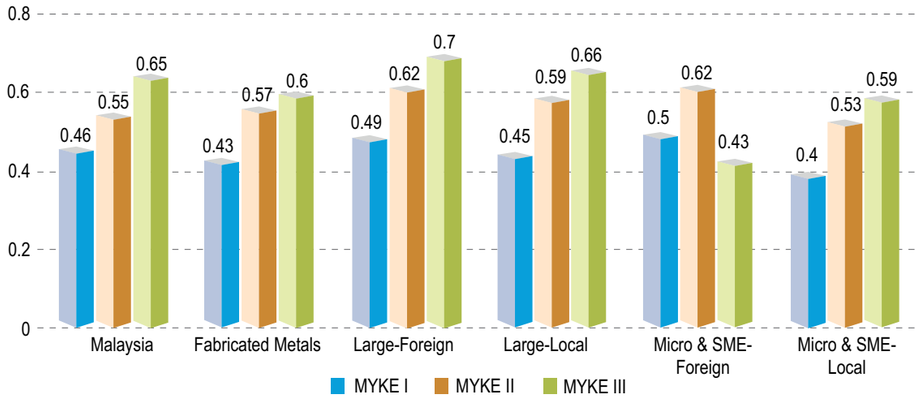
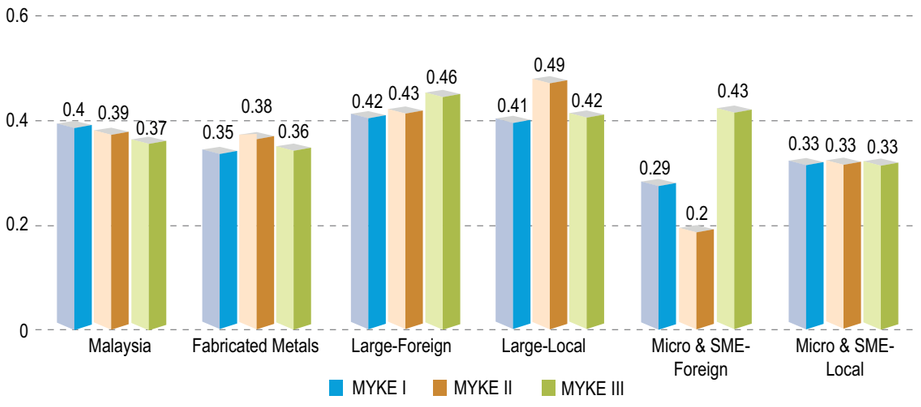


Figure 7.5: General Environment Awareness of the Fabricated Metals Industry



Similar trends are observed across the different categories of firms.

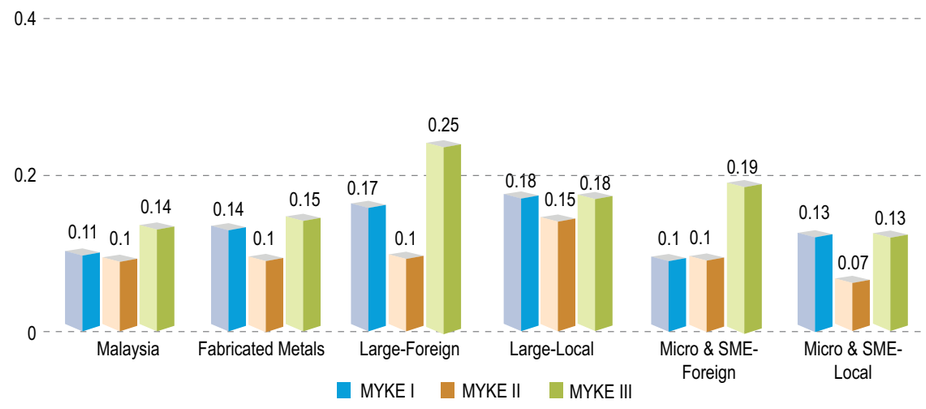
The figures suggest that from 2003 to 2014, there is little-to-no change among local micro, small and medium enterprises in their involvement with industry associations and government agencies to better understand Government plans and policies. However, foreign micro, small and medium enterprises are becoming much more active in their engagement with industry associations and government agencies.

7.4 Knowledge Actions

7.4.1 Knowledge Generation

In 2003, the score of knowledge generation was above the national aggregate level, fell slightly in 2007 and recovered by 2014 (see **Figure 7.6**). The trend is observed across all categories of firms, and by 2014 the score (0.15) is markedly close to the Malaysian industry aggregate (0.14). Large foreign firms (0.25) scored highest in this aspect, indicating higher activity in patent and copyright -filling, as well as R&D activity.

Figure 7.6: Knowledge Generation Activity in the Fabricated Metals Industry

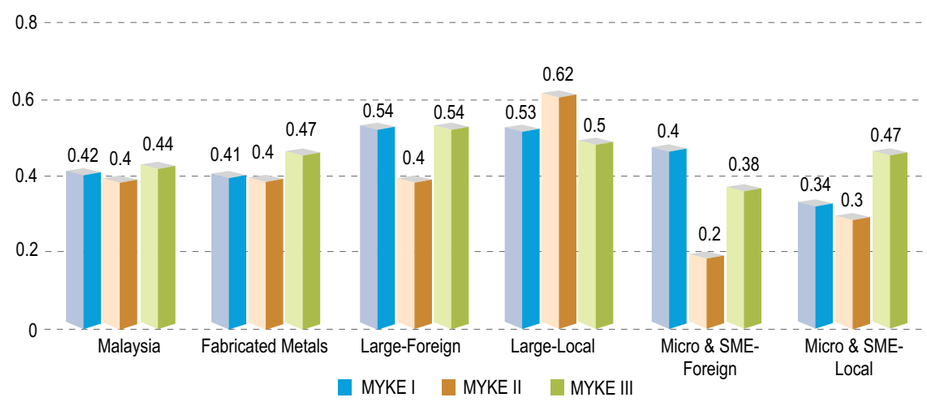


7.4.2 Knowledge Sharing

The score of knowledge sharing in fabricated metals industry remained around constant with minor fluctuations between 2003 and 2014, stabilising at 0.47 in the most recent term (see **Figure 7.7**). This score is marginally higher than the Malaysian industry average (0.44).

Large firms, both foreign (0.54) and local (0.5) score relatively high in knowledge sharing compared to smaller firms in 2014. This is because large firms are more likely to have project management teams and other structured approaches to facilitate knowledge sharing. Large firms are also more likely to use electronic means for disseminating knowledge resources internally as well as externally with partners in the supply-chain. In addition, local smaller firms have also demonstrated some measureable improvement – the performance scores of local micro, small and medium firms increased from 0.34 in 2003 to 0.47 in 2014.

Figure 7.7: Knowledge Sharing Activity of the Fabricated Metals Industry

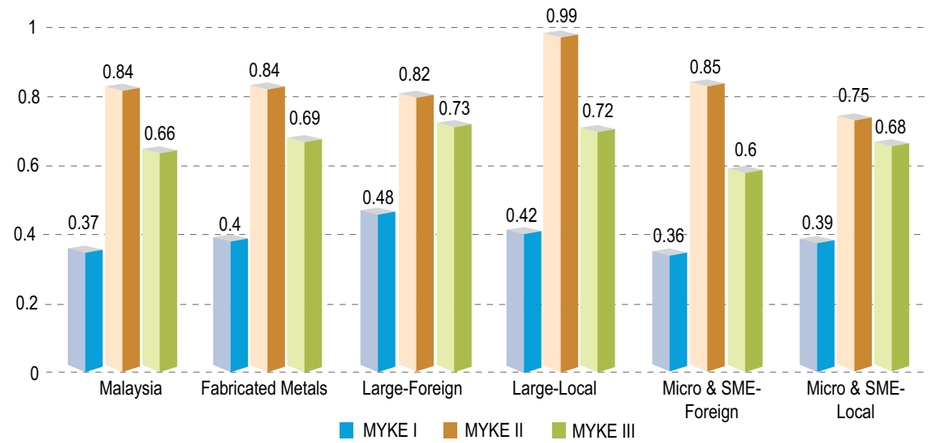


7.4.3 Knowledge Utilisation

Score of knowledge utilisation in fabricated metals industry increased by a large margin from 0.4 in 2003 to 0.84 in 2007, and then declined to 0.69 in 2014 (see **Figure 7.8**). Despite the volatility in performance, the industry has constantly scored above the Malaysian industry aggregate for all periods. This is unsurprising, as firms in the fabricated metals industry are proactive in their use of knowledge in order to realise maximum gains in production.

Large firms (both foreign and local) do better in knowledge utilisation, compared to smaller firms, scoring 0.73 and 0.72 respectively in 2014.

Figure 7.8: Knowledge Utilisation Activity of the Fabricated Metals Industry

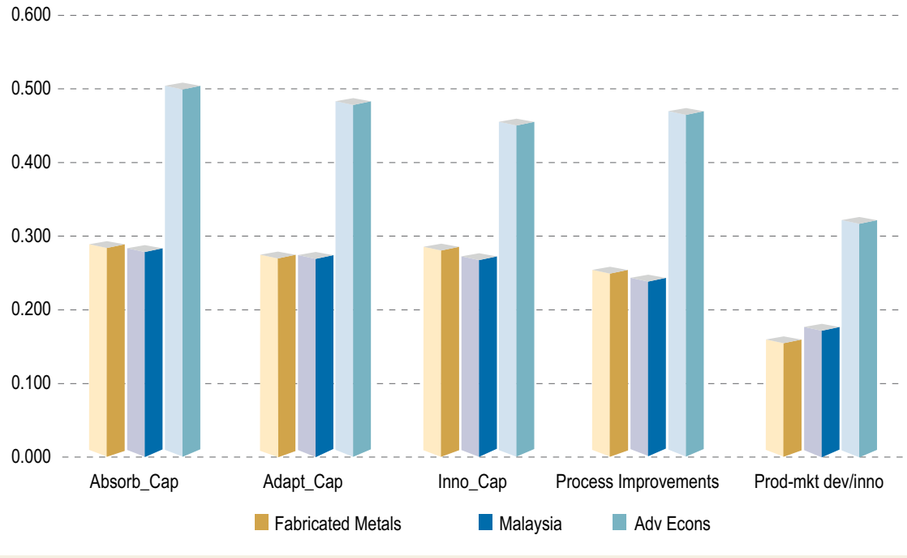


7.5 Dynamic Capabilities Profile for Fabricated Metals Industry

Dynamic capabilities endow firms with the ability to change and adapt to competitive pressures and changes in the external environment, and comprise three identifiable components – absorptive capability, adaptive capability and innovative capability. Firms with low levels of dynamic capabilities struggle to adjust to the changing competitive and/or structural landscapes. Conversely, those with higher level of dynamic capabilities are able to take advantage of change to build positions of competitive strength.

Fabricated metals industry in Malaysia demonstrates mixed performance across the three components of dynamic capabilities. In 2014, the fabricated metal industry's absorptive and innovative capabilities scored higher than the Malaysian industry aggregate; adaptive capability, however, was marginally below that baseline (**Figure 7.9**). Such mixed results are also visible in innovation outcomes, where the industry scores higher than national aggregate in terms of processes innovation but lower in terms of product-market development.

Figure 7.9: Dynamic Capability Profile of the Fabricated Metals Industry



7.5.1 Absorptive Capability

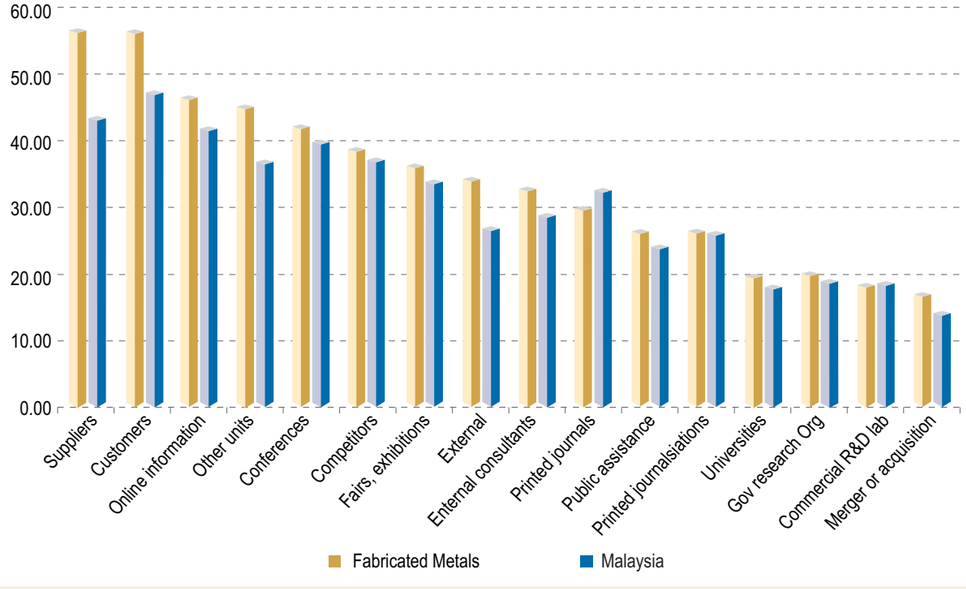
Absorptive capabilities endow firms with the ability to acquire knowledge from external resources and be able to systematically store it for future use. The fabricated metals industry performs slightly above the Malaysian industry aggregate (see **Figure 7.9**). This means that firms have the ability to collect and store new knowledge and information from external sources, including customers. However, transfer of learnt knowledge within firm through formal mechanisms appears to be weaker.

The fabricated metals industry gets its information and knowledge from different sources (**Figure 7.10**). The top three sources of knowledge are suppliers, customers and online information. This demonstrates that suppliers and customers are the main focus of intelligence and source of information for the fabricated metals industry. The industry has close linkages with suppliers. Learning from internal units is also an important part of knowledge capability building for the fabricated metals industry. The fabricated metals industry sources knowledge at a higher level than the Malaysian aggregate across most categories of knowledge sources.

7.5.2 Adaptive Capability

Adaptive capability refers to firms' ability to configure structures, people and resources in order to allow the use of knowledge to create specific outcomes. The fabricated metals industry is almost on par with the Malaysian industry aggregate in its ability to use learnt knowledge within the firm (see **Figure 7.9**). Therefore, firms in the industry are able to respond to changes and opportunities to some degree.

Figure 7.10: Sources of Knowledge in the Fabricated Metals Industry



The skills profile of firms in the fabricated metals industry shows heavy reliance on business administrative skills (see **Figure 7.11**). The second and third largest groups after business administration are engineering and E&E engineering graduates. The industry also hires computer science graduates and other graduates of the natural sciences. These categories feature at a level higher than national aggregate. There is a much lower number of biotechnology and social science graduates. The presence of engineering graduates is not surprising given the nature of industry. Possessing adequate skills and expertise is fundamental in adaptive capability of the firm. The skills profile shows that the fabricated metals industry has potential to rise up the value chain ladder.

Figure 7.11: Skills Profile of the Fabricated Metals Industry

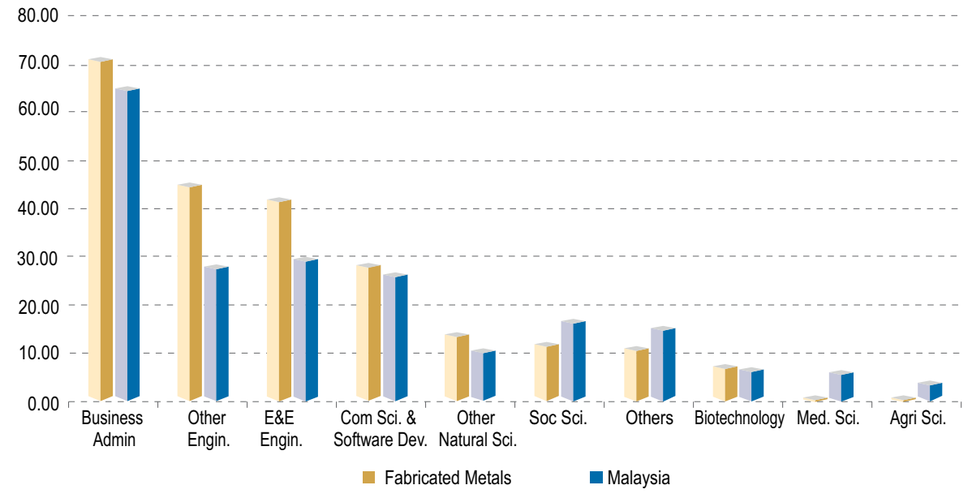
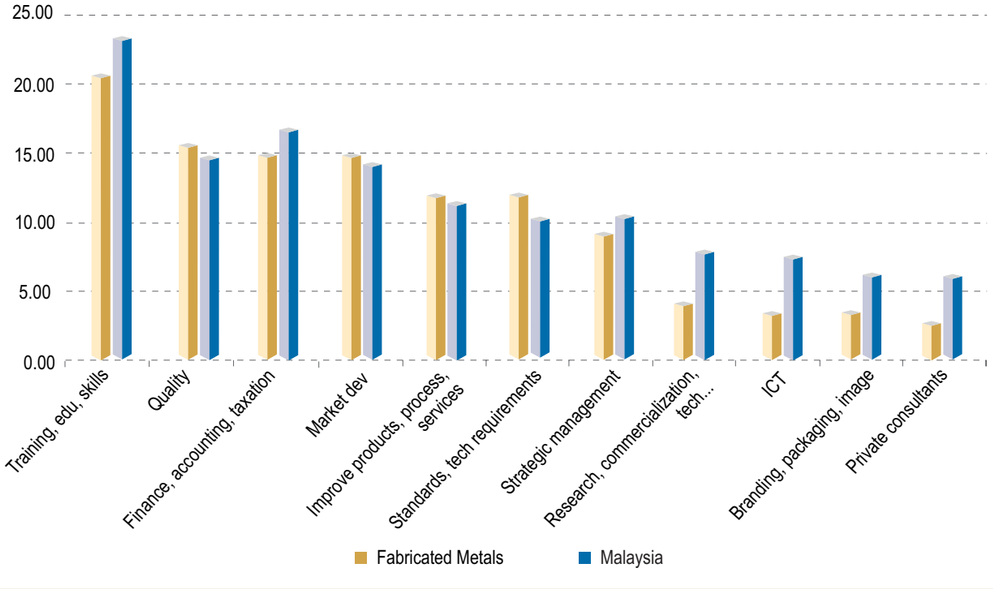


Figure 7.12: Role of Institutional Environment in Skill Building of the Fabricated Metals Industry



Malaysia's institutional environment has a minimal role to play in building capabilities for the industry. A range of assistance and support to firms is provided by various institutions in Malaysia such as government agencies, industry association and universities. Human capability building in the form of training, educational and skill enhancement takes place within the fabricated metals industry (see **Figure 7.12**). Firms in the fabricated metals industry also receive help to improve their operations capability through assistance on quality, as well as products and processes improvement. Nevertheless, the fabricated metals industry seems to receive lower support compared to other industries.

7.5.3 Innovative Capability

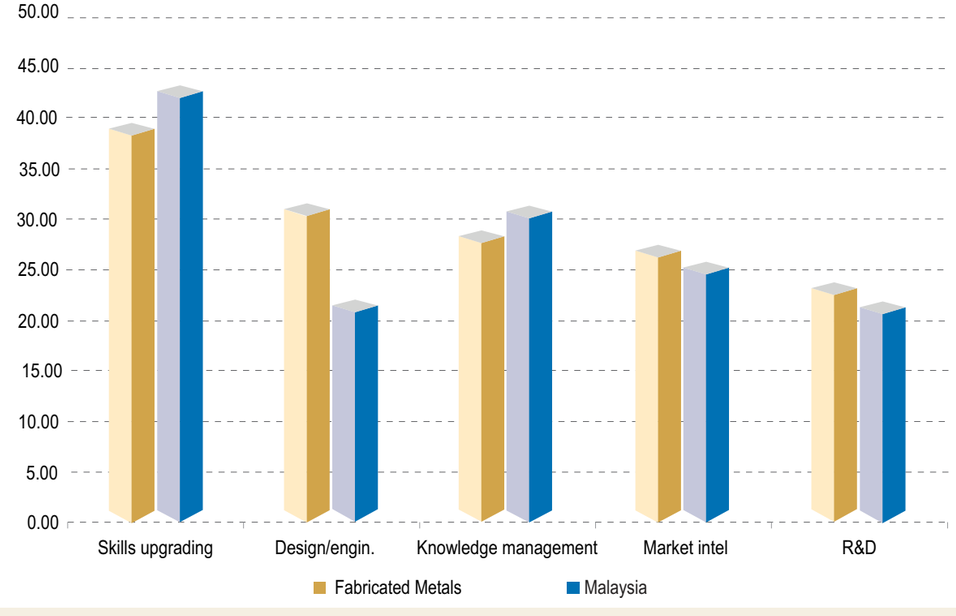
Firms with high innovative capability are able to put in place and execute processes that integrate organisational resources to take advantage of the opportunity. In terms of innovative capability, fabricated metals score is above the Malaysian industry aggregate (see Figure 7.9), suggestive of medium capabilities in assimilating learnt knowledge and technologies within processes for innovation.

A number of activities, such as skills upgrading, knowledge management, developing market intelligence, R&D and design engineering, are important to the development of innovation capability. Firms in the fabricated metals industry exhibit an involvement with skills upgrading and knowledge management that is lower than national aggregate (see **Figure 7.13**). Meanwhile, these firms devote higher investment to design engineering and are slightly higher than the industry average in terms of market intelligence and investment in R&D.

7.6 Outcomes of Dynamic Capabilities in the Fabricated Metals Industry

The Malaysian fabricated metals industry shows heavy reliance on the domestic market, which contributes to 72.49% of total revenues (see Figure 7.14). Additionally, sales revenue from within the state comprises 48.05% of the total, indicating corridor influence. Breakdown of export sales show the regional market (ASEAN plus Japan, China and South Korea) to account for 17.64%, with international sales at only 9.88%. This shows the Malaysian fabricated metals industry to be gradually expanding its presence regionally, although its focus remains on the home market.

Figure 7.13: Knowledge Intensive Activities in the Fabricated Metals Industry



In terms of process improvements, the industry is above the Malaysian industry aggregate (see **Figure 7.9**), shows fabricated metals industry players to possess sufficiency in the three dynamic capabilities so as to create internal process improvement. The biggest strength relative to the Malaysian industry average is in technological and marketing process improvement. As indicated by industry players during interviews, due to the nature of the industry, almost all players (including the small players) possess ISO certification. In other words, the management processes are very well-structured and systematic.

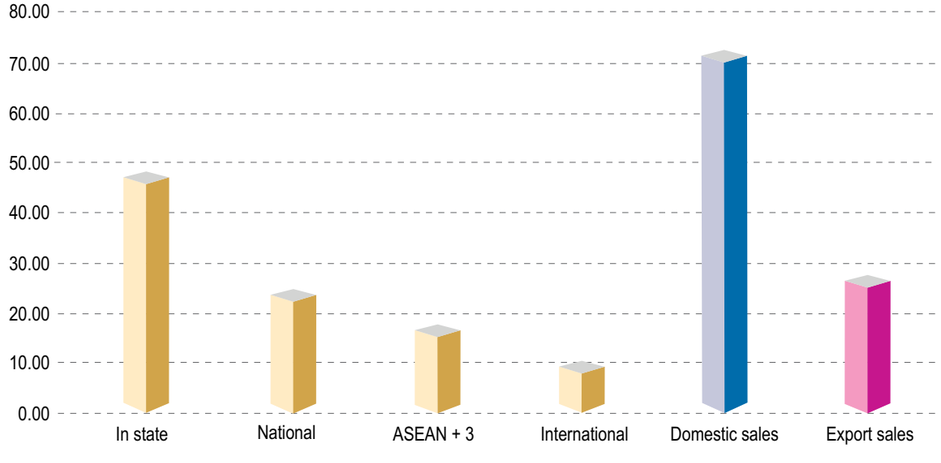
In terms of product and market development, the fabricated metals industry scored below the Malaysian industry aggregate in 2014 (see **Figure 7.9**). From 2007 to 2014, most fabricated metals industry players did not manage to introduce many new products to the firm or to the market.

The strategic profile of firms in the fabricated metals industry indicates a strong presence of Defender firms (51.08%). These are firms whose purpose is to maintain their existing market share rather than try to find new opportunities, and as such are not likely to influence change in the marketplace. Reactors make up the second largest group of firms (23.74%). Reactors are not proactive firms. They only react to events that happen around them and change is instigated by external pressures. Taken together, these two groups constitute almost 75% of firms

in the fabricated metals industry. The combined presence of Defenders and Reactors in the industry is higher that the Malaysian aggregate.

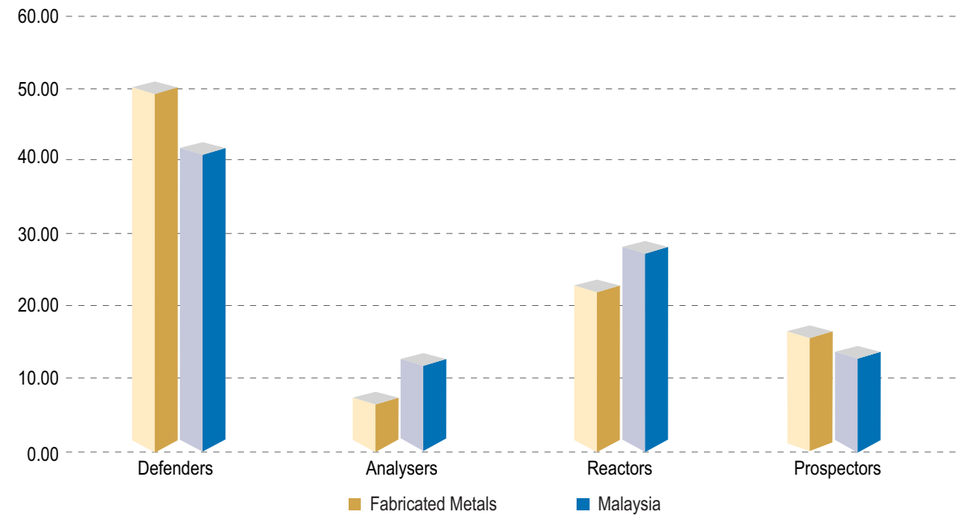
The third group, Prospectors represent 17.27% of firms in the industry, and feature at higher level than industry aggregate. Finally, the smallest group is constituted by Analyser firms (7.91%), and is at a lower level than industry aggregate. Overall, although the majority of firms in the fabricated metals industry are Defenders and Reactors, the industry has more prospectors than the aggregate level, indicating that more than average effort at innovation is taking place within the industry.

Figure 7.14: Market Presence of the Fabricated Metals Industry



Note: The results are based on survey data.

Figure 7.15: Strategic Profile of Firms in the Fabricated Metals Industry

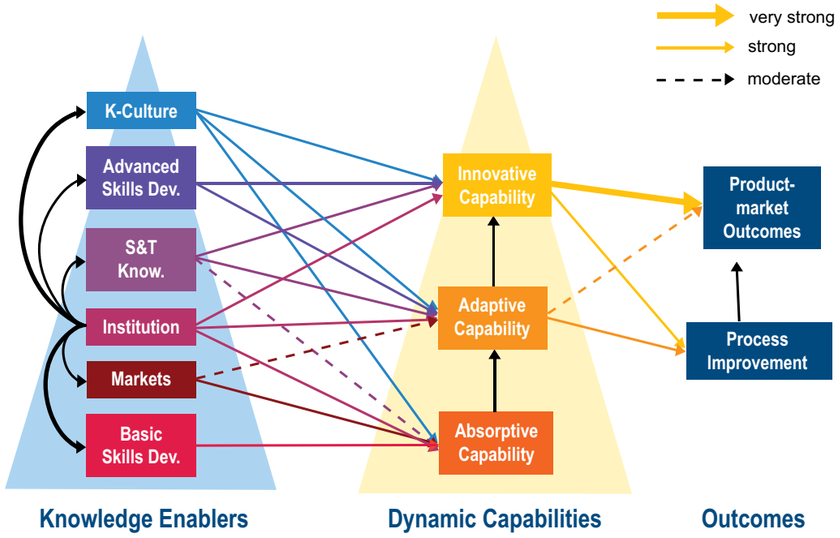


7.7 Relationships between the Key Blueprints of the Fabricated Metals Knowledge Ecosystem

In this section, the impact of knowledge enablers on dynamic capabilities and its subsequent impact on economic outcomes for the fabricated metals industry is scrutinised. The knowledge ecosystem for the fabricated metals industry is comparatively evaluated next to the fabricated metals industry in advanced sector countries (i.e., Canada, Japan, Russia, Turkey, and United States). Based on content analysis of in-depth interviews and data obtained from DOS, the fabricated metals industry is classified as an Adapter in Malaysia. This industry does not possess the level or type of knowledge possessed by a Pace-setter industry, but it has sufficient knowledge to use advances made by Pace-setters and other firms to create further improvements in the innovation such that it is able to capture significant market share. Firms in the industry tend to be fast followers, quickly seizing opportunities to their advantage, and often supplanting Pace-setters in the process.

Figure 7.16 shows the knowledge ecosystem for fabricated metals in advanced sector countries. The knowledge ecosystem for fabricated metals firms in the advanced sector nations enables the development of all three components of dynamic capability, which in turn drive both process innovations as well as product innovation. In advanced sector countries, adaptors are strongly attuned to the external market place and exhibit strong absorbability capability. They use market and customer knowledge to good effect through a process of internal adaptation in response to external opportunities. This is captured in the form of organisational adaptive capability. Strong absorptive and adaptive capabilities of firms in the advanced sector countries enable them to leverage upon these capabilities to build innovative capability. Possession of such level of dynamic capabilities allows these firms to create improvements in their processes as well launch products that are highly attuned to the needs of end-customers and are globally competitive.

Figure 7.16: Knowledge Ecosystem of the Fabricated Metals Industry in an Advanced Country



Note: Very strong impacts are represented by the bolded line, strong impacts are represented by normal lines and moderate impacts are represented by dotted lines.

The knowledge ecosystem for the fabricated metals industry based on Malaysian data collected by DOS is shown in **Figure 7.17**. The knowledge ecosystem in the Malaysian fabricated metals industry is significantly weaker than that in advanced sector country benchmarks. A number of notable differences between an advanced sector country setting and the Malaysian industry fabricated metals industry setting can be observed. In advanced sector countries, the overall dynamic capability position of firms is strong. Specifically, in advanced sector countries, a rich tapestry of enablers is observed in the nurturance of the different dynamic capabilities in the fabricated metals industry. In contrast, in the Malaysian setting, dynamic capabilities are weakly nurtured. In Malaysia, markets drive innovative capability. In advanced sector countries, absorptive capability is built through market sensing, and only thereafter is it transposed into innovative capability through internal adaptation and readiness of firms to take advantage of absorptive intelligence. Advanced sector country Adaptors leverage on their internal competencies to release products that closely match market needs. Moreover, their strength in adaptive capabilities allows them to create process efficiencies. Malaysian firms, lacking strength in adaptive capability, are not able to release globally competitive novel products. Much of their science and technical effort is devoted to understanding technical advances made by others (absorptive effort), rather than focusing on break-through advances in products themselves. The innovative capability component is such that it can only yield process improvements, and little in the way of globally competitive new products.

In advanced sector countries, there is significant collaboration with universities, research institutes and other institutions to create all three dynamic capability components. This is missing within the Malaysia setting. There appears to be weaknesses in S&T and its institutional leverage for the benefit of firms in the fabricated metals industry. The results indicate that non-withstanding Malaysia's efforts for skills development, the fabricated metals industry continues to suffer from S&T weaknesses that result in significant opportunity cost for the industry.

Figure 7.17: Knowledge Ecosystem of Fabricated Metals Industry in Malaysia

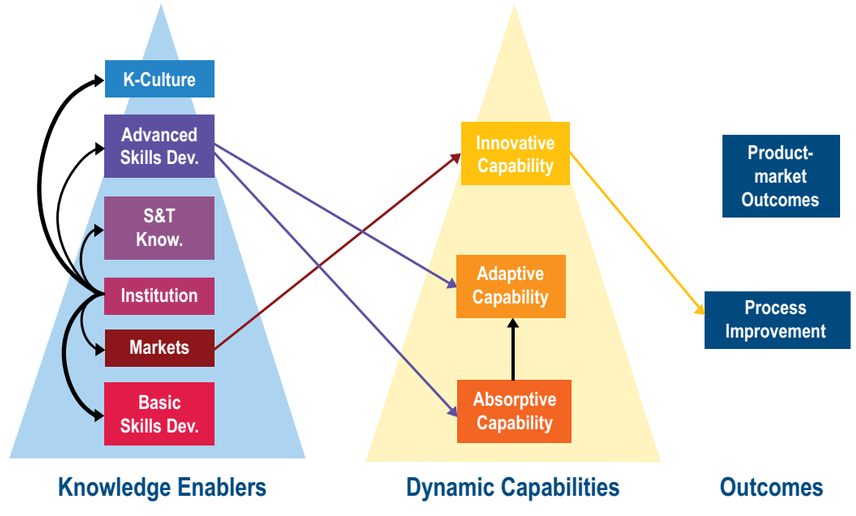


Figure 7.17 shows weaknesses in the Malaysian ecosystem in developing the necessary strength across all three dynamic capability components. Due to this deficiency, Malaysian fabricated metals firms are only able to create process improvement with little translation into product innovation. This suggests that Malaysian fabricated metals primarily compete on the basis of price in existing product-markets rather than through the development of premium high value-add products.

Table 7.3 provides a summary of the comparative standing of the fabricated metals industry ecosystems in advanced sector countries and in Malaysia. It highlights the key areas of comparative deficiency of Malaysian fabricated metals industry's knowledge ecosystem relative to the strengths found in advanced sector countries.

Table 7.3: Knowledge Enablers and Dynamic Capabilities for the Fabricated Metals Industry

Advanced Countries	Malaysia
Basic skills have a **positive impact** on absorptive capability. In advanced sector countries, the level of basic skills required for high-end metal fabrication processes is high. These countries have a long history and accumulated knowledge. The development, nurturance and dissemination of knowledge is strongly driven by government agencies, regulatory authorities, industry associations and institutions of learning.	Basic skills **fail to show significant impact** on absorptive capability. The Malaysian fabricated metals industry relies heavily on low skill labour force that is comprised by a significant number of foreign workers. The transitory nature of employment of these workers means they are unable to systematically contribute to absorptive capability. It is necessary to address this inadequacy in order to lay the absorptive capability foundation for effective feed into higher dynamic capability components.

Table 7.3: Knowledge Enablers and Dynamic Capabilities for the Fabricated Metals Industry (cont'd)

Advanced Countries	Malaysia
Market intelligence has a **strong positive impact** on absorptive capability, and a **moderate impact** on adaptive capability. Suppliers, customers, competitors, external consultants and commercial R&D centres play a significant role in the absorption of new knowledge, particularly in the use of new technology. This nexus of collaboration and intensive sharing conduces development of new technologies, systems and processes. The combination of these different knowledge sources helps in the development of technologically advanced materials and leads to a variety of high value-added metal and steel products.	Market intelligence has a **positive impact** on innovative capability. The fabricated metals industry relies on suppliers, customers, competitors, external consultants and commercial R&D centres to inform its innovation agenda. However, lacking sufficiency in higher level dynamic capabilities and knowledge base to materialise the innovation agenda into novel high value-added products, Malaysian fabricated metal firms are only able to use such knowledge to fashion improvements in their processes in an attempt to become price competitive.
Institutions are **strong enablers** of the knowledge ecosystem and have **direct strong and positive impacts** on all three dynamic capability components. Institutions, such as industry associations, government research institutions and universities, play a key role in creating a vibrant fabricated metals industry ecosystem. Many of these institutions play a proactive involvement in nurturing dynamic capabilities components. They act as direct enablers of skills development and upgrade of talent, as well as key drivers of leading-edge R&D that generates the next generation of products and services to sustain the industry's long term future.	Institutions are **indirect enablers** for all the different knowledge enabling components, but they **do not create any direct impact** on the three dynamic capability components. Institutions, such as industry associations and universities, play a role in manpower training for the industry. However, these institutions do not directly improve the dynamic capability components of firms in the fabricated metals industry.
S&T knowledge has a **positive and moderate impact** on absorptive capability and, **positive and strong impacts** on adaptive and innovative capabilities. Fabricated metal firms in advanced sector countries are highly focussed on creating technical advances as part of advanced engineering, materials science and R&D efforts. Such efforts enable them to be at the forefront in developing new systems, products and even services in the industry. With very strong foundations in basic and applied research in	S&T knowledge has **no direct impact** on the dynamic capability components of absorptive, adaptive and innovative capabilities. S&T only has indirect effects through its interaction with other enabling factors. A majority of companies in the Malaysian fabricated metals industry are users of new technology and innovations developed elsewhere. The key influence of S&T is through its advanced skilled personnel who focus primarily on translating others' knowledge and advances into potential products that can be adapted for use in markets, particularly

Table 7.3: Knowledge Enablers and Dynamic Capabilities for the Fabricated Metals Industry (cont'd)

Advanced Countries	Malaysia
science, technology and engineering, firms in the fabricated metals industry are able to find broad cross-cutting applications for their advanced steel and metals.	local ones. Most of the S&T knowledge is funnelled through a small number of well-trained scientists and personnel and is not widespread within the organisation.
Advanced skills have **a positive and strong impact** on innovative and adaptive capabilities. Advanced sector countries dedicate significant resources to improve the quantum and quality of manpower with the development of specialist areas and higher degrees aligned with the changing and current needs of industry, as well as charting future possibilities for industry. The effect of a strong 'quadruple-helix' enables those with sound theoretical knowledge to reconfigure and apply their knowledge in advancing the fabricated metals industry. New materials, advances in nanotechnologies, new approaches to architecture and designs are opening new frontiers in end user applications of advanced fabricated metals.	Advanced skills have a **positive and significant impact** on absorptive and adaptive capabilities. In contrast to advanced sector countries, the impact of advanced skills in the Malaysia fabricated metals is inclined towards the lower level components of dynamic capabilities (absorptive and adaptive) rather than towards the higher level adaptive and innovative capabilities. This is suggestive of either a different of focus of attention or a deficiency in the quality or quantum of advanced skills as to enable innovative capability and its associated product outcomes. To address the deficiency, it is necessary to strengthen both the quantum and quality of knowledge and its focus within the fabricated metals industry. Currently, a majority of the highly skilled workforce in the fabricated metals industry are translators or users of new technology rather than producers of cutting-edge knowledge and applications.
Knowledge culture has a **positive and strong impact** on all three dynamic capabilities. In advanced sector country, organisational culture is strongly geared towards rapidly learning the most recent advances. This, coupled with their close understanding of the market place, allows them to create fine-tuned adaptations and applications that satisfy the needs of end customers and clients. This features as a key in the strength of their dynamic capabilities, and consequently allows the launch of new products or services that possess enhanced features demanded by the market place at affordable prices for target segments.	Knowledge culture **does not feature as key driver** in the nurturance and development of dynamic capabilities. In many Malaysian firms, organisation culture is strongly hierarchical. Innovation and R&D are confined to select individuals or a small department within a firm. Few resources and investments are channelled into R&D activity. A strong task and hierarchy structure means the predominant culture is one in which innovation is not considered by individuals to be part of their role; this role is left for higher echelons or specialist experts brought in specifically for the task. Such internal reflexes diminish the internal innovation imperative. Consequently, there is negligible organisation wide

Table 7.3: Knowledge Enablers and Dynamic Capabilities for the Fabricated Metals Industry (cont'd)

Advanced Countries	Malaysia
	dynamic capability building. The organisational culture of Malaysian firms is to modify existing products and services in order to improve price competitiveness. This culture is reinforced by a lack of research institutions doing the ground breaking work that could fuel innovations and create a culture of innovation in the industry.
The continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** Sound R&D coupled with strong personnel with basic, technical and R&D experience help the industry to be resilient in absorbing new knowledge. Strong foundation of knowledge helps firms adapt external knowledge and reconfigure it into new innovations that improve processes and enhance quality of existing products and services. As workers gain more experience, they are able to translate external and internal knowledge into new products and services for both local and global markets. As firms intensify their technology and knowledge capabilities, some firms are able to successfully produce new process improvements that often can translate into new lines of products and services.	The continuum from absorptive capability to adaptive capability to innovative capability is **present.** The skill composition of the sector comprises a large portion low skill workers and a smaller segment of highly skilled trained workforce. This provides the industry some degree of sufficiency to build dynamic capabilities, but the quantum and quality of individuals with specific skills for innovation in the form of the higher order adaptive and innovative capabilities command further strengthening. A majority of effort is situated in building manufacturing capability that is able to produce others' innovations at lowest cost.

The translation of dynamic capabilities to economic outcomes for the fabricated metals industry for both advanced sector countries and Malaysia is shown in **Table 7.4.** The study found that the impact of dynamic capabilities components on economic outcomes for the fabricated metals industry in advanced sector countries and Malaysia differ significantly. In advanced sector countries, innovative capability has a positive impact on new product development, but also helps improve process improvement. Adaptive capability plays a role in both process improvement and new product development. Also, very importantly, there is a very strong positive flow from process innovation to product innovation indicating that process innovation features as a key enabler to not only complete on new product features but on cost effectiveness as well.

The case of the Malaysian fabricated metals industry suggests different flows. Only innovative capability is observed to have a significant impact on outcomes, and its effect is focused solely on process improvement. The Malaysian fabricated metals industry is geared primarily to compete on price rather than innovating their products. Many of the local firms are driven by a highly cost conscious domestic and local regional market. The consequence of the weakness in dynamic capability is suggestive of a lack of global competitiveness of Malaysian firms in high value fabricated products. Particularly notable is the weakness of innovative capability to create new products and the absence of adaptive capability effects, which features so prominently in the advanced sector countries.

Table 7.4: Dynamic Capabilities and Economic Outcomes for the Fabricated Metals Industry

Advanced Countries	Malaysia
Adaptive capability has a **positive impact** on process improvement and product-market innovation. Adaptive capability of firms plays a key role in driving process-led efficiencies in order to launch globally competitive new products and services. Fabricated metals firms in advanced sector countries are highly capable of adapting new technologies and scientific advances to create customised high value-add applications for their market customers.	Adaptive capability **does not have any impact** on process improvement or product market innovation. With insufficient strength and depth in their dynamic capability components due to weakness in the enabling factors, adaptive capability of Malaysian fabricated metals firms fails to deliver significant benefits. This reduces the potential gains in terms of process improvement or new product enhancements that could be accessed if adaptive capability position was stronger and correctly leveraged.
Innovative capability has a **positive impact** on product market outcomes and a **moderate impact** on process improvement. Strong innovative capability powered by strength in its S&T base, high R&D investment and strong interaction and collaboration among stakeholders contributes to technical and scientific advances that can be embedded into materials to create wider range of possibilities in end-use of advanced metals and steels.	Innovative capability has an **impact on process** improvement. Innovative capability **does not have any impact** on product market outcomes. The industry focus is strongly geared to manufacture of materials that contains technical and product advances of others, but do so in a price competitive manner. The primary focus is on reducing the cost of manufacturing and using it as a weapon for competition.
Process improvement has a **very strong positive impact** on product market outcomes. Strong dynamic capabilities backed by a rich web of enablers allow firms in this sector to not only create enhanced and novel products but manufacture them very efficiently. Strong institutional collaborations, high technical and scientific skills allow for translational impact across processes as well as products. Possessing strong process capability, fabricated metals firms in advanced sector countries are able to amplify the leverage and benefit of product-market innovations.	Process improvement **does not have any impact** on product market outcomes. Without the process improvement creating enhancements in product innovations, firms in the sector are able only to focus on an existing portfolio of products and hence become totally reliant on price competitiveness for market success.

7.8 Summary: Key Trends, Challenges, Way Forward and Best Practices

7.8.1 Industry Trends

The fabricated metals industry exhibits average performance in terms of knowledge resource foundations. In 2014, almost all elements of knowledge enablers in the fabricated metals industry are on par with Malaysian industry average. The largest gains in the strength of the knowledge foundations were made between 2003 and 2007. From 2007 to 2014, change was marginal with a mix of improvements and declines.

Given its average knowledge base, the industry is also average in terms of dynamic capabilities. In 2014, the industry's absorptive and innovative capabilities were slightly above Malaysia industry aggregate whereas adaptive capabilities were marginally below the Malaysia industry aggregate. In terms of innovation outcomes, the industry scores higher than national aggregate in processes innovation but lower than industry aggregate in product-market development. Due to the nature of the process technologies in the industry many of the firms in companies have well-structured processes supplemented by ISO certification.

The fabricated metals industry is a core sector in Malaysia, supplying essential raw materials to automotive, manufacturing, transport equipment, construction, machinery and other industries. Despite the stable demand for fabricated metals, the industry is undergoing a decline in output and revenue. A number of factors have contributed to this. One of the foremost factors arises from the fact that the local market is flooded with cheap steel from China. This is despite the government's effort to initiate anti-dumping measures. To circumvent these some Chinese exporters have added substances, such as boron and chromium into carbon steel that they export, to create an alloy composition. This allows them get around the barriers. Adding to the challenge, the industry is inefficient in its production due to low economies of scale. This contributes to escalating operating costs and loss of competitiveness.

7.8.2 Challenges

The fabricated metal industry plays an important role in all spheres of economic activity in Malaysia. The local consumption of fabricated metals is expected to rise with on-going construction of properties and mass rapid transit projects. However, the industry faces a number of challenges that need to be overcome. These challenges are discussed below.

Institutions:

- Lack of coordination between industry, associations, and other stakeholders internal and external to the industry; hence the development of the industry has been rather ad-hoc.

- Lack of endorsement and recognition by government for local players, especially SMEs. Instead tenders and contracts tend to be given to foreign firms or big players in the industry (MNCs and GLCs). This contributes to monopoly power.

- The industry is highly diverse in its product portfolio and needs. Institutional agencies find it difficult to fully appreciate the diversity and cater to the specific needs of the different sub-sectors.

- Absence of policies to protect the local industry within the supply chain. In contrast, countries such as China include "local content" clauses for foreign firms planning to open their operations.

- Silo mentality within the supply chain network leads to lack of strategic development of the industry.

Basic Skills Development:

- Shortage of skilled and semi-skilled labour has created heavy reliance on foreign workforce. The local industry needs to develop training programs to equip the local workforce for the technical jobs in the industry.

- There is a significant need to enhance applied knowledge if the sector is to remain competitive into the future. Technical product knowledge as well as basic skills in marketing and branding are weak in comparison to other industries and foreign firms.

Advanced Skills Development:

- Heavy dependence on foreign technology and knowledge, little emphasis on developing local innovation. Industry's focus on short-term and routine production renders it unable to build advanced skills required for R&D driven innovations.

- Industry is primarily a user, not developer, of technology. Little investment is made in R&D facilities or advanced skills development.

- Specialist trainers are not locally available and trainings costs are high. This reinforces shortage of R&D and skills development cycle.

S&T Knowledge:

- Heavy reliance on suppliers, customers, competitors, external consultants and commercial R&D centres for knowledge. Firms in the industry are almost entirely focussed on cost reduction.

- Low level of investment for development of highly skilled personnel with the requisite expertise to tackle frontier global developments in the industry. Insufficient S&T expertise within the industry to tackle major issues shaping the industry, both upstream and downstream.

Market Intelligence:

- Heavy reliance of firms on technology, raw materials as well as finished fabricated metal from foreign countries (e.g. China) that are considerably cheaper than local suppliers. China's cost advantage arising from economies of scale and well incentive support creates intense cost pressure on local manufacturing and fabricating industry.

- Insufficient policy based protection to prevent "dumping" from foreign players. The industry's output is falling despite the rising consumption of steel. Demand for steel is driven by robust construction sector and a numerous mega-projects (e.g. Mass Rapid Transport) yet the local industry is unable to take advantage of this.

Knowledge Culture:

- Absence of R&D culture to encourage innovation in the industry.

- Industry dominated by firms with "hierarchical conglomerate" culture. Wide prevalence of secrecy leads to little knowledge sharing and knowledge generation at the collective industry level.

- Conglomerate approach leads to internalisation of activities within the firm. This leaves little opportunity for cross-fertilisation and sharing of knowledge. Large firms try to become "islands" operating across the supply chain, leaving little space for the development of smaller firms. Internalisation and strong loyalty practices squeezes out SMEs from significant parts of the market place. Eventually such activities result in a vacuum of entrepreneurial R&D led firms.

7.8.3 Way Forward

The fabricated metals industry of Malaysia is at a decisive juncture that necessitates it making certain strategic decisions about its future viability. To enhance the knowledge content of the industry the following recommendations are proposed below.

Recommendation 7.1: Reduce Cost of Technology Dependence through Development of Skilled Machinery Engineering and Maintenance Services

- Comprehensive talent and skills management strategy needs to be formulated to fill gaps in current skills. Future industry skill needs must be mapped out and actions taken to develop quality and quantity of skills for long term success.

- Training and skills building education needs to be developed by institutions (universities, colleges, etc) to cater to the future needs of the industry. Requires close collaborative interaction between industry and educational sectors.

- Collaboration with foreign companies to train and equip existing local talent to manage and handle technology and machineries involved in the industry (e.g. short courses, TVETs, certifications in skills and trades etc.). This must be supported by specific technology transfer mechanisms, such as Teaching Company Associates (TCA).

- Nurture the establishment of a local maintenance and servicing industry capable of cater to fabricated metal industry needs, through a planned process of training and hiring of local talents.

Recommendation 7.2: Balance Industry Capital Needs Versus Risk Perception through Awareness and Education of Financial Institutions of the Industry's Specific Needs and Challenges

- Financial incentives should be made available to firms within this industry (loans, credit facilities, bonds etc.) to encourage and ensure the industry remains competitive and relevant to the economy as a whole.

- Formulate communication strategy to create trust and understanding between the industry and the financial industry by raising awareness of the specific characteristics and nature of the fabricated metals and steel industry. This will help growth of both small and large local firms.

Recommendation 7.3: Strategic Approach to Manage Over-Capacity in the Industry Created By FDI and "Dumping" By Foreign Players

- Government should strategically evaluate and scrutinise the type of new start-ups and investments into the industry. Careful assessment of the FDIs is required to ensure that policy action does not add to existing capacity and increase the level of competition for local manufacturers.

- Anti-dumping policy needs to be strongly enforced to stop unfair competition. A fair system needs to be developed for both local and foreign companies, as well as small, medium and large firms operating in the industry.

Recommendation 7.4: Establish an Independent Panel for Quality Screening to Create a Level Playing Field

- An independent panel needs to be established in order to arbitrate and provide good governance to industry players, especially in establishing credence of claims made by various foreign players of superior quality vis-à-vis local industry. This will help create a level playing field.

- The independent panel is to provide technical, objective evidence and recommendations to the industry. The panel as part of its remit should evaluate the quality of the materials sourced from foreign countries as well as those manufactured and fabricated locally.

Recommendation 7.5: Strategic Approach to Industry Capability Development Coupled With Malaysia First Policy Built on Transparency, Openness and Competition in the Tendering Process

- Strong partnership between industries relying on the fabricated metal industry has to be formed in order to ensure nurturance of the ecosystem. This requires strategic alignment of the industries to create space for win-win partnerships to flourish.

- Put in place policies to encourage foreign and local firms to use locally manufactured raw materials (e.g. construction industry, automobile makers, etc.). This will provide a much needed boost to the industry and the local economy.

- Stronger endorsement for local players is required to allow local firms to establish a stronger competitive footing. For instance, provide rebates for use of local raw materials or finished products for firms when it is directed to high value added activities.

- Open tender for projects both by the government and private sector to ensure its transparency, openness and fair competition.

- Tighter enforcements for smuggling of raw materials and finished products into Malaysia need to be enforced.

- Develop skills and capabilities based on future anticipated key developments. Industry fore-sighting needs to dovetail with skill and capability building.

7.8.4 Best Practices

The fabricated metals industry has great opportunities for growth, as it is an enabling industry for a wide range of industries such as automobile, aerospace, rail, machinery manufacturing, etc. In most leading industrial countries, significant resources are invested to continuously strengthen the competitiveness of this industry, which has a strong spill-over impact on other complementary industries. To enhance the global competitiveness, the local industry should consider learning from and implementing the following best practices on a wider scale.

Best Practice 7.1: Reduce Cost of Technology Dependence through Development of Skilled Machinery Engineering and Maintenance Services

India – National Steel Policy

- National Policy facilitated creation of additional capacity, removal of procedural and policy bottlenecks that impede industry development; increased investment and R&D activities, and helped in the building of infrastructure to support the industry towards its goal.

- Allowed carefully controlled Foreign Direct Investments such that they boosted development of local players in the steel industry.

- Improved Intellectual Property laws to encourage R&D investment.

- Special economic zones (SEZs) to create internationally competitive regions in which exporting businesses could base their operations.

Best Practice 7.2: Balance Industry Capital Needs Versus Risk Perception through Awareness and Education of Financial Institutions of the Industry's Specific Needs and Challenges

China – Steel Policy

- Provides direct subsidy to the industry in the form of tax refunds, discounted interest rates, and other preferential policies.

- Restricted foreign investment to protect local firms in their early stage of development.

- Provides grants to support energy and raw material for the production of steel.

- Targeted infrastructure development – to build and finance industrial parks and R&D hubs.

- Preferential loan and credit facilities that favour state-owned firms to build strong economies of scale.

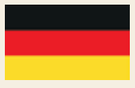
- Import barriers, including higher tariffs and other practices that discriminate against foreign equipment and technology. This is to ensure that surrounding ecosystem is inhabited by local firms. It also helps break any long term dependency on foreign firm throughout the supply chain.

Best Practice 7.3: Strategic Approach to Manage Over-Capacity in the Industry Created By FDI and "Dumping" By Foreign Players

United States, State of Georgia – Fabricated Metal State

- Statutory incentives – sales tax and tax credits exemptions to encourage job creation within the industry.
- Quick Start Program – focused on skill based training programs for the industry at no cost for qualified new and expanding firms. Training programs are tailored to meet the needs of the industry.
- Hope Grants – financial aid for the local people who are enrolled in the public colleges to obtain a certificate or graduate diploma in the fabricated metal related studies.
- Technical colleges – establishment of 25 technical colleges, working collaboratively with the "Quick Start Programme" offering a versatile, state of the art workforce and comprehensive development programme.
- Industry Resources – State of Georgia is home to leading research institutions specifically geared to provide R&D insights and help drive innovation in the industry.

Best Practice 7.4: Establish an Independent Panel for Quality Screening to Create a Level Playing Field



Germany Steel Industry and the Fraunhofer-Gesellschaft

- Germany provides strong state support to its industries. A key pillar of support is provided by the Fraunhofer-Gesellschaft, a part publicly-funded research organisation that provides access to new and innovative technology and knowledge for companies that would otherwise find the cost prohibitive. The team continuously monitors the quality of the products and services provided by the local industry; and benchmarks them against global best players. Significant resources and effort are invested to ensure local industries have access to leading-edge technology and manufacturing practices that enable them to be globally competitive. Efforts are also made to export the knowledge and technology to industries in other countries – a way to expand the high quality German manufacturing practices and footprint across the globe.
- The Fraunhofer Society is a research organisation with 67 institutes spread across Germany, each focusing on different fields of applied science. Steel and fabricated metal are one of the areas that receive significant resources and R&D funding to continuously improve and create innovative technologies. The steel and fabricated metal industry is regarded as the foundation of the Germany engineering and equipment manufacturing industry. The industry employs around 24,000 people, mainly scientists and engineers, with an annual research budget of about €2.1 billion.
- The steel industry places strong importance on vocational education, in which academic study is combined with on-the-job training. In this respect, each course has an industrial placement and internship learning components. After receiving their training and certification, most graduates have very little difficulty obtaining employment with the local industries.
- German steel companies are also beneficiaries of close linkages across industries, such as automobile, aerospace and other key manufacturing industries. Strong collaboration and cooperation among these industries is underpinned by the adoption of Industry 4.0 framework, which enables the operations of the firms to be seamlessly integrated.

Best Practice 7.5: Strategic Approach to Industry Capability Development Coupled With Malaysia First Policy Built on Transparency, Openness and Competition in the Tendering Process

Japan Iron and Steel Federation

- The Japan Iron and Steel Federation (JISF) is a nationwide representative body of the Japanese steel industry that ensures the local industry continuously enhances its innovative capacity and global competitive position.
- JISF plays active role in conducting surveys and analysing steel production, shipments, inventory, import and export and real consumption trends. Its compilation of comprehensive data is highly useful for all its members in allowing them to examine their internal operations in the short run, as well as plan long term strategies. Large numbers of firms benefit from the data analytics, including the country's major iron and steel producers, trading companies, and organisations engaged in steel distribution (Japan Iron and Steel Federation, 2015).
- JISF is also a strong lobby group for the industry. It plays a key role in fostering strong partnership between universities, research institutes and the industry. JISP also plays an active role in nurturing and fostering strong partnerships and collaborations between SMEs and the MNCs in the industry. These activities ensure that the local supply network is strong, agile and sustainable in meeting the needs of both local and global players.
- JISF is also a strong advocate for Japanese industries and government agencies to support local industries by using local products and services.

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CHAPTER 8

KNOWLEDGE CONTENT OF THE AUTOMOTIVE INDUSTRY

CHAPTER 8
Knowledge Content of the Automotive Industry

8.0 Introduction

In the developed countries, such as Europe and the US, the automotive industry is considered to be key driver of competitiveness due to the high level of investment funnelled into automobile R&D. The industry features heavily in national strategies and policies due to its profound relationship with energy, transport and climate change. Estimates by the Centre for Automotive Research (2014) suggest that the automotive industry accounts for 16% of total worldwide R&D funding across all industries, and auto-companies make up about one quarter of the top 20 corporate spenders worldwide. Without a doubt, it is a highly knowledge-intensive industry whose products are among the most sophisticated available to general members of the public.

A trade-mark feature of the automotive industry is high-tech manufacturing, involving unmanned production lines populated by sophisticated robots, state-of-the-art precision engineering tools and advanced materials. Leading-edge technologies are a staple of the factory floor, featuring novel, practical applications of nanotechnology, digital engineering and even biotechnology, all of which are managed through a complex system of production to control quality and costs.

Historically, many developed countries each had their own national auto-manufacturers; some like the UK had at least a handful. However, over the last few decades a good number have either closed operations during industry shake-outs or come out of the 1980-90s era as merged partnerships. Currently, the industry is dominated by big global players, who compete on the basis of economies of scale.

The network conglomerate of Volkswagen (VW) is a typical embodiment of modern global automobile company. It creates economies through sharing of its manufacturing platform and modularity in component parts across its brands, such as Audi, Seat, Skoda, Bentley and Porsche. Toyota is a another example, owning Daihatsu Motors, Hino Motors, Fujitsu Heavy industries, Isuzu Motors and Tesla Motors, and has a range of joint ventures as well as technical and parts alliances. The global economic crisis had a strong impact on the automotive industry, especially in Europe and less so in Asia. A number of European companies narrowly escaped closure, having to rely on initiatives such as scrapping schemes and fiscal stimulus packages.

Even after a spate of shake-outs and rationalisations, the global automotive industry remains in the grips of a price war. The automobile conglomerate networks have created imperfect competition in which there is too much of everything: too many companies, too much capacity, and too much redundancy, all combining to create intense price competition in the marketplace. Worldwide competition is unlikely to abate, as Chinese and Indian manufacturers enter the fray as emergent global players, adding more capacity and competition to an already saturated industry.

8.1 Key Developments and Initiatives

8.1.1 Malaysian Automobile Industry

Malaysia embarked on its manufacturing journey in the mid-1960s, and the automotive industry featured as one of the initiatives to kick-start the decades-long undertaking. In order to break the stranglehold of complete build unit (CBU) imports into the country, the government formulated a set of policies to assemble and manufacture components locally. Following this, the government enacted further policies to encourage development. The imposed heavy tax levy on fully imported CBUs required foreign firms operating in Malaysia to source a percentage from local component manufacturers, and dealers to renew import licenses bi-annually.

By 1967, six assembly plants had come into being, as joint ventures between local and foreign companies. Companies such as Swedish Motor Assemblies Sdn Bhd, Asia Automobile Industries Sdn Bhd and Tan Chong Motors are early examples. However, despite expanding to 15 assembly plants and significant incentives, the level of local content remained small. This persisted until 1980s, when the serving Prime Minister, Dr. Tun Mahathir made the crucial decision to set up a national car manufacturer. This began the second phase in Malaysian automobile development.

In 1984, under the National Car Project, Perusahaan Otomobil Nasional (Proton) was inaugurated as a joint venture with Mitsubishi Motors of Japan. The first car, Proton Saga, rolled off the assembly line in 1985. Over the years Proton expanded its range to release mid-sized saloons. Eight years on, the industry was given another boost, with the set-up of the second national car, Perusahaan Otomobil Kedua Nasional Sdn Bhd (Perodua) in 1992. Perodua arose out of joint venture with Daihatsu Motor Co and a number of other partners including Mitsui & Co Ltd of Japan, Med-Bumikar Sdn Bhd, UMW Corporation Sdn Bhd and PNB Equity Resources corporations Sdn Bhd. In contrast to Proton, the focus of Perodua was on the compact car segment.

The launch of the two national car projects catalysed the development of component parts and ancillary service industries. Subsequently, in 1994 Industri Otomotif Komersail (Inokom), a joint venture between HICOM and Isuzu, and in 1997 the Malaysian Truck and Bus (MTB), a collaboration with Hyundai Motors of Korea, emerged on the Malaysian automobile scene focusing on small trucks and bus manufacture.

The modern automobile industry is composed of original equipment manufacturer (OEM) and assembler companies, the component parts supply industry, the maintenance and ancillary parts and support services.

8.1.2 OEMs and Auto-Assemblers

Aside from the national OEMs such as Proton and Perodua, there are nine local and foreign assembler operations. Among them include local companies such as Naza Automotive Manufacturing Sdn Bhd, as well as a full complement of international marques from Europe, such as Mercedes Benz, BMW and Peugot; and Japanese corporations such as Toyota, Nissan, Mazda and Mitsubishi. The local companies and international marques contract local manufacturing and assembly plants in order to comply with local content regulations. In addition, there are small niche players in the sports and specialist car industry such as TVR Sports Sdn Bhd and Bufori Motor Car Co. Sdn Bhd.

8.1.3 Component Parts

There are over 800 component producers in Malaysia with a 300,000-strong workforce in the automobile industry (Sultana & Ibrahim, 2014). The vendors are categorised into first-, second- and third-tier suppliers by the major OEMs and assemblers. The largest assemblers operate their own supply chain networks in the form of vendor associations: Proton Vendors Association, Klub Vendor Perodua, Toyota Suppliers Club and Honda Suppliers Club. Estimates suggest that around 70% of the vendors are locally owned, while the remaining are foreign or with a foreign majority (Natsuda et al, 2013).

To enhance the capabilities of suppliers, numerous supplier development programmes are operating between OEM and assemblers and suppliers. Despite this the number of component manufacturers with the capability to design and develop to export standards remains small, at around 50 or so.

8.1.4 Maintenance and Ancillary Services

Other than dealerships of the major assemblers, the maintenance and associated service industry is dominated by large number of shop-lot entities.

Over the years, the Malaysian government has implemented through its agencies (MITI, MIDA, Malaysia Automotive Institute, Standards and Industrial Research Institute of Malaysia) a variety of programmes to boost productivity and competitiveness of the automotive industry. Most notable among these is the National Automotive Policy (NAP), with the aim of taking steps to build competitiveness of the industry. In its latest revision, NAP 2014 defines key policy aims to build competitive advantage in local automotive industry companies, particularly through provision of incentives for the manufacture of high value added parts and components as well as investment into hybrid vehicle and other related environment friendly technologies. Complementing this, MITI and Malaysia Automotive Institute (MAI) have formulated six roadmaps and implementation plans.

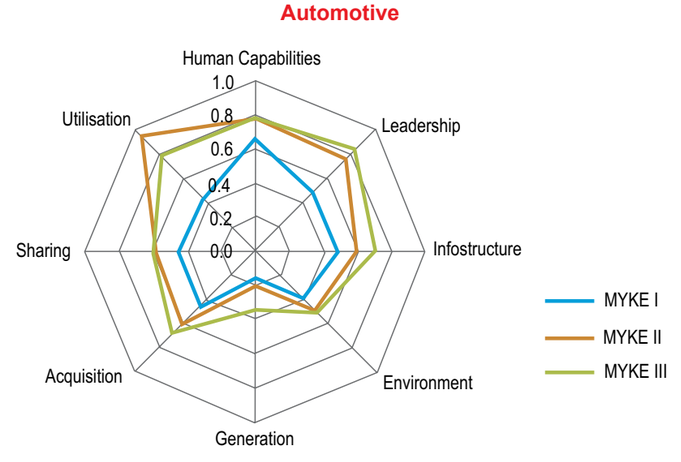
NAP 2014 builds on previous initiatives, such as the Industrial Adjustment Fund (IAF) and the Malaysia Japan Automotive Industries Cooperation (MAJAICO) both of which were started in 2006. The IAF was set up to provide automotive industry companies interest free loans and grants to build capacity and capabilities, whilst MAJAICO was introduced to learn from the Japanese technical as well as business skills and capabilities.

Not to leave behind the automobile maintenance and service industry, a programme to transform workshops - Automotive Workshop Modernisation (ATOM) was introduced in 2011 through the Ministry of Domestic Trade, Co-operatives and Consumerism (MDTCC) State Offices. The aim of the ATOM programme was to widen the range of repair and maintenance activities of workshops by providing funding to workshop owners for tools and equipment that allow for higher value added activities. In 2014, 208 automotive workshops participated, bringing the total since its introduction to 577 transformations of automobile workshops (Economic Transformation Programme [ETP], 2016).

8.2 Knowledge Content

The automobile industry's knowledge resource foundations provide guidance as to the level and trajectory of development of the industry. **Figure 8.1** shows changes that have taken place over the period 2003 to 2014, at the three points of time defined by MYKE I, II and III assessment. Positive progress is observable in most of the dimensions along the two categories of Knowledge Enablers and Knowledge Actions, though in some areas, especially knowledge utilisation, there is a drop during the MYKE II and MYKE III period.

Figure 8.1: Overview of Knowledge Enablers and Knowledge Actions for MYKE I, II and III



8.3 Knowledge Enablers

8.3.1 Human Capabilities

Under the ETP and the 11th Malaysia Plan, the government set the target of creating 3.3 million jobs and increase productivity level to reach RM933,000 in 2020 from RM77,100 in 2015 (Economic Planning Unit, 2015). The automobile industry features significantly in this goal by registering RM30 billion contribution to national GDP and accounting for more than 550,000 employees.

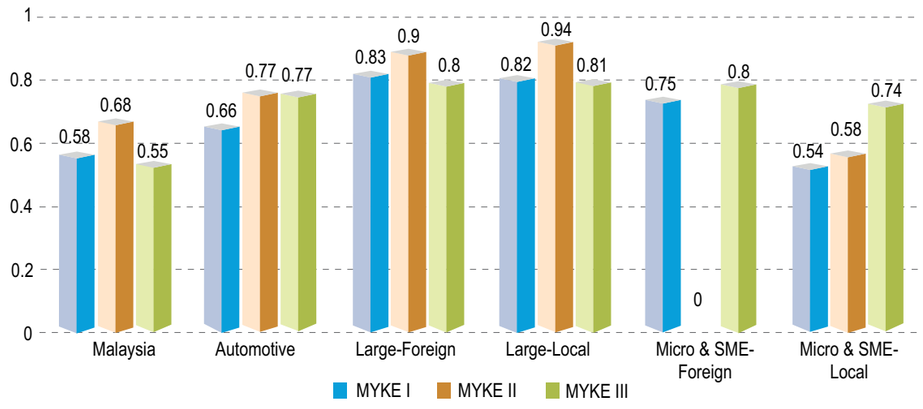
Human Capabilities in the automotive industry improved over the period of 2003 to 2007, but remained constant at an index value of 0.77 from 2007 to 2014 (see **Figure 8.2**). Looking beneath the aggregate figure for the automotive industry reveals a number of interesting features. Large local and foreign (large and SMEs) firms in the automotive industry did better in attracting skilled talent with degrees and also training of its employees compared to the national aggregate throughout the period. Local SME firms started from a lower base in 2003 and made some improvement by 2007, subsequently making a strong jump and exceeding the national aggregate by 2014.

Figure 8.2 shows the large local and foreign firms registered positive improvement from 2003 to 2007, but their human capabilities index dropped from 0.94 and 0.9 to 0.8 and 0.81 respectively from 2007 to 2014. In contrast SMEs, foreign and local, grew in the period from 2003 to 2014.

Especially in the case of the large automotive industry firms, attracting human talent has become increasingly difficult owing to the emergence of stiffer competition from other industries; the services industry is the main contender for talent acquisition. SMEs, however, have fared much better in attracting and building human capabilities – this is in part a result of supplier development programmes instituted by the larger auto-assembly and manufacturing firms, as well as government initiatives to strengthen SME capability in the parts and components industry.

Besides competition for talent, another disruption for human capabilities acquisition stems from the higher skill demand over time by the players in the automobile industry who have engaged in earnest with the challenge of R&D and innovation. The level of education required to work in the automotive industry has risen significantly between MYKE I and MYKE III, requiring increasing number of employees to possess specialised vocational qualifications, baccalaureates and even higher degrees. The automotive firms' drive toward plant automation and process mechanisation has pushed this even further. Faced on the one side by increasing competition for human talent and on the other side by higher skill requirement, many of the larger automobile firms have struggled to balance demand with a supply of requisite human talent.

Figure 8.2 Human Capability of the Automotive Industry

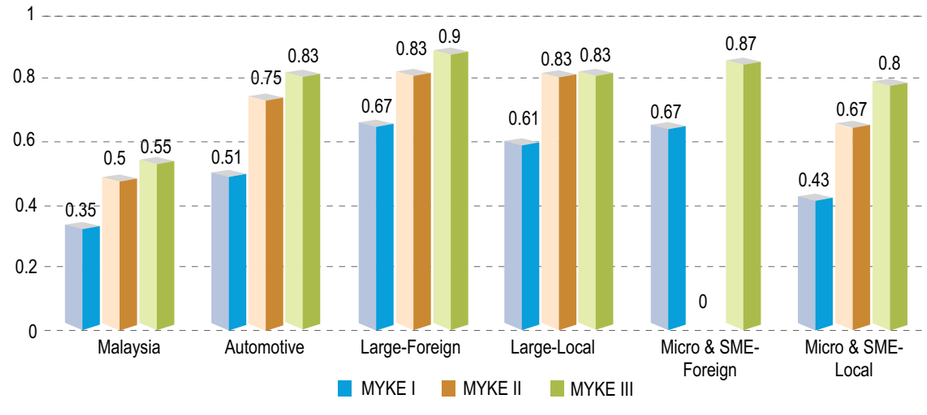


8.3.2 Knowledge Systems and Leadership

Malaysian automotive industry companies show very positive year-on-year improvement with respect to instituting formal approaches to the management of knowledge by developing strategies, structures, systems, processes and committees for knowledge capture, generation and use. **Figure 8.3** shows that the automotive industry is above the aggregate level for Malaysian industry in its approach to management of knowledge within organisations. There is consistent improvement in this regard, irrespective of firm size or their point of origin.

There is no sizeable gap between foreign firms of varying sizes concerning the systematic nature of their approach to knowledge. This is also true for large local firms when compared to foreign firms. Interestingly, it is the SMEs have improved by the largest margin. In 2003, local SMEs were very similar in their approach with the aggregated Malaysian industry but by 2007 they had taken positive strides and surpassed the industry-wide average. By 2014 local SMEs had caught up with larger local and foreign counterparts in managing and leveraging on knowledge.

Figure 8.3 Knowledge Leadership in the Automotive Industry



8.3.3 Technology and Infostructure

Technology-based infostructure of the Malaysian automotive industry firms improved consistently over the period 2003 to 2014. In 2003, foreign firms, large and SMEs, were better-endowed in terms of computer availability and access than local counterparts. However, local companies, large and small made significant strides to improve the condition of their infostructure provision.

8.3.4 Knowledge Environment

At the aggregate level automotive industry, firms show good level of engagement with the broader institutional knowledge environment. Firms in the industry make significant efforts to understand knowledge initiatives from government agencies, work through their associations and collaborate on projects with universities and institutes. These efforts led to gradual increases over time, which contrast with the incremental decline in engagement over time of Malaysian industry as a whole.

Figure 8.4 Technology and Infostructure of the Automotive Industry

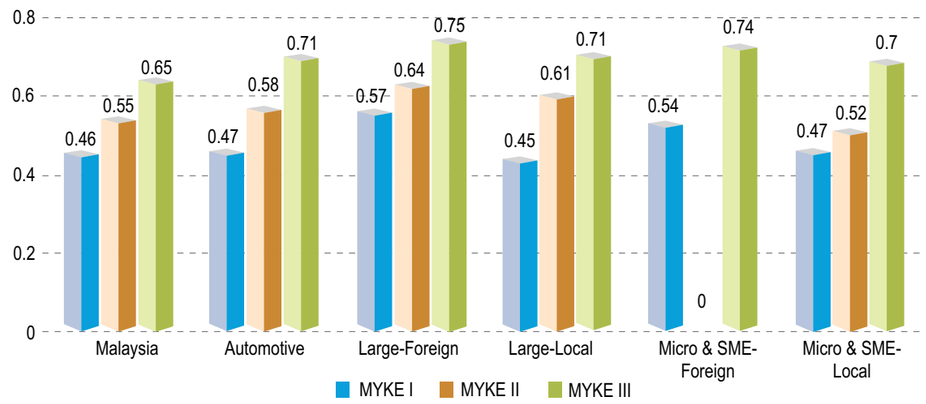
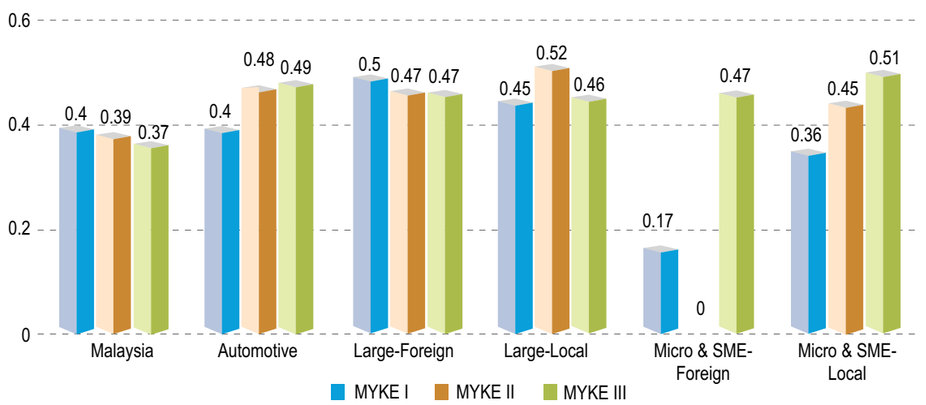


Figure 8.5: General Environment Awareness of the Automotive Industry



In 2003, foreign large companies exhibited the highest level of awareness and engagement with the government's knowledge plans and programmes. However, this declined by 2007 and thereafter has remained constant. Large local firms increased their efforts between 2003 and 2007, but this had fallen by 2014 to a similar level as the large foreign firms.
In contrast to the larger firms, SMEs, both local and foreign, show increased awareness and engagement across the entire time period. This heightened engagement appears to be in response to the government's provision of incentives and programmes to strengthen the parts and component supply chain of the automotive industry. In particular, foreign small firms have improved their engagement in order to take advantage of the various capability enhancing initiatives.

8.4 Knowledge Actions

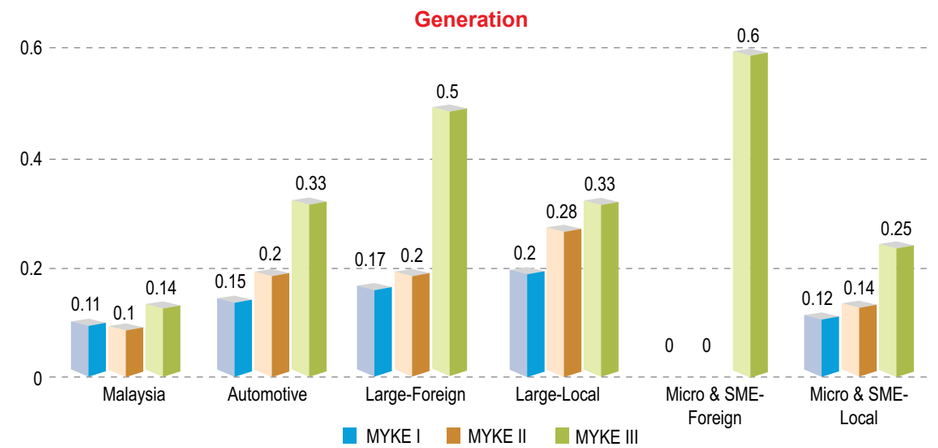
8.4.1 Knowledge Generation

The automotive industry compares favourably to Malaysian industry aggregate in terms of R&D engagement, and patent and copyright filings. Unfortunately, the Malaysian aggregate for knowledge generation has remained uncomfortably low over the period of 2003 to 2014. In contrast, the automotive industry aggregate has consistently improved, albeit gradually, over the period. This pattern of improvement is experienced across all categories of firms, large or small, foreign or local.

Up to 2003, large foreign players were engaging minimally in knowledge generation and R&D. Their operations primarily comprised assembly or import of CBU. The mainstay of knowledge generation took place in parent company locations or elsewhere in their operations. This largely remained the case until 2007. Indeed, during this period, large local firms were exhibiting significantly higher knowledge creation. Positively, local large firms were attempting to engage in the knowledge creation process but unfortunately the rating of their outcomes, much like the Malaysian industry aggregate, remains low.

The changed environment for foreign companies between 2007 and 2014 saw a more than two-fold leap in their knowledge generation activity. The more open and conducive environment coupled with a changed government approach has created opportunities for foreign firms which they are now able to exploit through R&D and customised innovation to service Malaysian auto-manufacturer needs. Over this period, large local companies, though they were improving, fell well behind foreign companies. This is alarming, given that these large local players were supposed to be at the vanguard of technological advancement and knowledge creation. The profile of local SMEs is similar to that of the large local companies. They are progressing in the right

Figure 8.6: Knowledge Generation Activity in the Automotive Industry



direction but the rate of knowledge creation is not in keeping with that of foreign firms.

On an even more significant note is the level of innovation and knowledge creation arising from foreign SMEs. Smaller foreign firms even outstrip their larger counterparts. Such firms are strongly focused on taking advantage of the drive to innovate locally, contextualising their value proposition for the needs of domestic auto-assemblers and suppliers. This pattern aligns with developed country settings where high levels of innovation and knowledge creation takes places in highly entrepreneurial small firms.

8.4.2 Knowledge Sharing

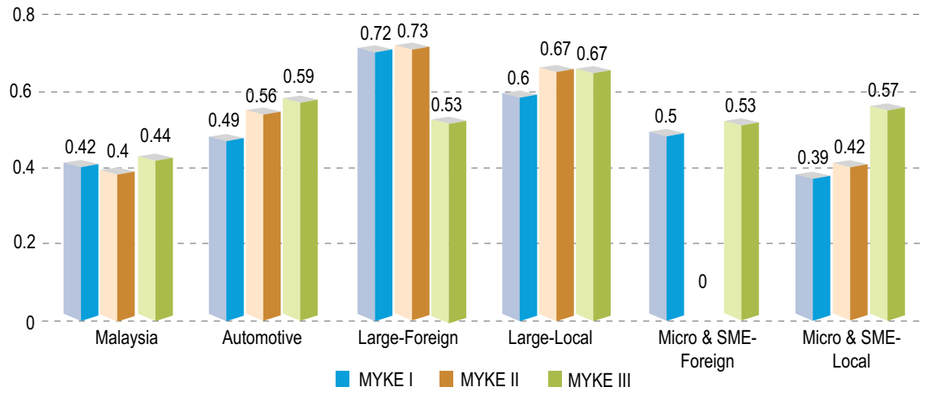
In keeping with other elements, knowledge sharing in the automobile industry is somewhat higher than the Malaysian aggregate. However, each firm category demonstrated varying development behaviours that are worth noting. Large foreign firms exhibited the highest knowledge sharing in 2003 and 2007. Interestingly, by 2014 this fell below that of large and small local firms.

Foreign SMEs show only a small gain over the period of 2003 to 2014.

Local firms appear to be engaged with much higher knowledge sharing than foreign counterparts. Large ones show improvement in knowledge sharing, albeit incremental. The biggest improvement took place within the smaller, local SME segment, overtaking foreign SMEs and almost catching up with large foreign companies. This may be as a consequence of capability maturing of local firms, especially of the larger local firms. Large auto-companies, having themselves absorbed certain skills and built capabilities, are now running supplier development programmes and sharing expertise and knowledge. The biggest beneficiaries of these sharing partnerships and programmes are small local companies who are rapidly trying to scale up their competencies in keeping with an increasingly competitive marketplace.

Another possible explanation of the drop of knowledge sharing is that as competition heats up and local players grow in competitiveness, foreign firms become more cautious in sharing. This effect is likely more pronounced if foreign firms begin to create new knowledge through R&D within Malaysia, and thereafter begin to take stronger steps to protect their IP.

Figure 8.7: Knowledge Sharing Activity of the Automotive Industry



8.4.3 Knowledge Utilisation

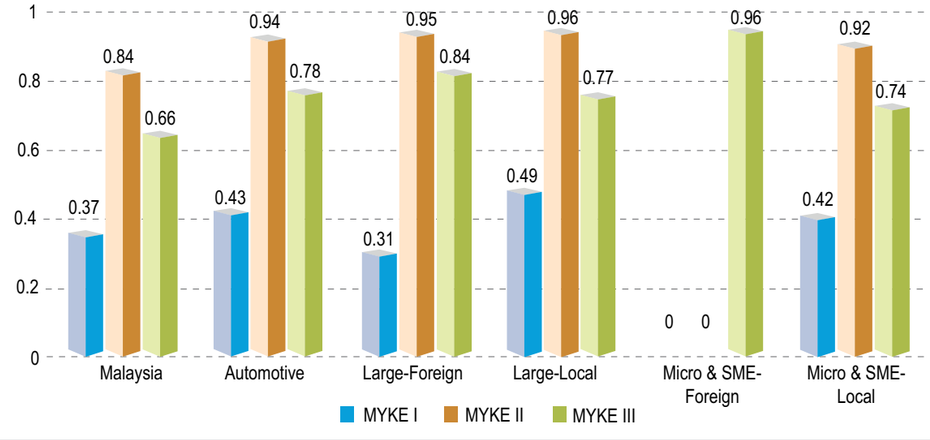
All automotive industry firms irrespective of size, local or foreign have made a concerted effort at knowledge utilisation. Starting from a low base in 2003 to 2007, firms have made strong headway to leverage the knowledge that they possess to create outcomes. The interesting feature of the improvement is that local firms have closely rivalled foreign firms in their efforts to utilise knowledge. Likewise, small firms have kept pace with large firms. Having made good progress in knowledge utilisation, companies were unable to sustain to the momentum over the period 2007 to 2014. During this period, all companies except foreign SMEs, declined in their knowledge utilisation. This consequently stultified their knowledge creation efforts. In keeping with high knowledge creation, foreign SMEs in turn have exhibited the highest level of knowledge utilisation in 2014.

Overall, firms in the automotive industry generally show positive development and progress over the period covered by MYKE I, II and III. Knowledge enablers all improved over the period 2003 to 2014. In 2003, Malaysian firms possessed a weak knowledge infostructure and low level of formalisation in their approach to knowledge management and accompanying systems and processes. By 2007 they had made significant strides in their awareness and approach to the management of knowledge by taking advantage of a range of initiatives arising out of NAP and other government programmes promoting knowledge management. The automotive industry's ability to attract and develop human talent also showed a very positive trend until 2007, but did not improve much thereafter. This plateau of human capabilities can be associated with greater competition for talent and the rise of other industries that are perceived to offer attractive careers for graduates and highly skilled workers. Particularly, the services industry has offered well-paying jobs in urban areas.

Additionally, the automotive industry's awareness and engagement with the local institutional environment remained inconsistent, at times making headway and at other times regressing. In particular, large firms that were highly engaged in 2003 receded in engagement, whilst SMEs both local and foreign came to the fore, in response to government initiatives to strengthen automotive industry SMEs.

Knowledge actions of the sector display interesting development. Knowledge sharing increased in the period between MYKE I and MYKE II but faltered thereafter. Knowledge utilisation which experienced a very sharp jump between 2003 and 2007, moved in the opposite direction, falling to an index value of 0.78 from a high of 0.94. Despite considerable progress, outcomes in terms of knowledge creation and innovation remained disappointingly low, even though they improved over time and were much better than the average of Malaysian industry.

Figure 8.8: Knowledge Utilisation Activity of the Automotive Industry



8.5 Dynamic Capabilities Profile for Automotive Industry

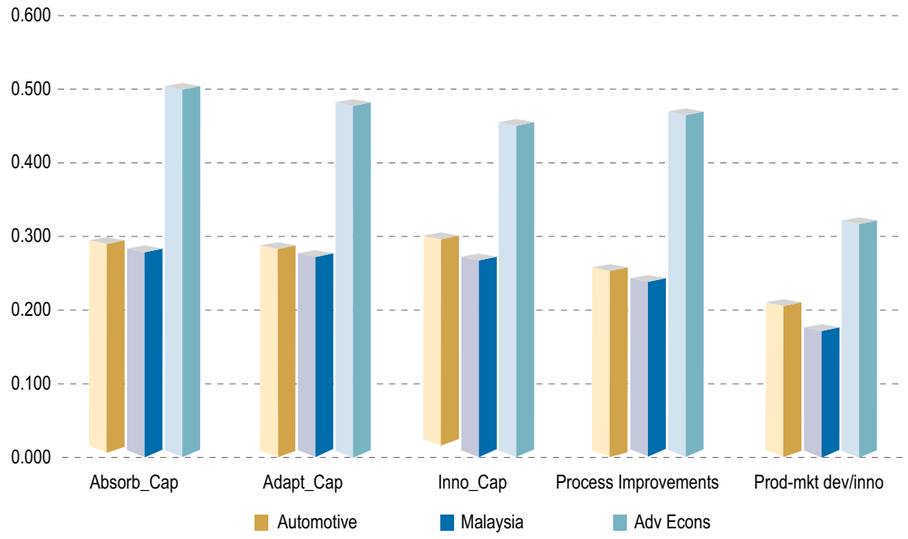
Dynamic capabilities undergird a firm's success over time, in that they endow firms with the ability to change and adapt to competitive pressures and changes in the external environment. Dynamic capabilities at the fundamental level are constituted in the form of absorptive capability, adaptive capability and innovative capability. Firms with low levels of dynamic capabilities struggle to adjust to the changing landscape of competition. Firms with a higher level of dynamic capabilities are able to take advantage of change to build positions of competitive strength.

The automotive industry has been gradually strengthening its capability over time through numerous initiatives, both firm-driven and government-led. As earlier sections highlight, the automotive industry has built strong knowledge based foundations, and these over time have been transformed into a positive endowment of dynamic capabilities that underpin long term competitiveness.

Figure 8.9 shows the auto-industry's dynamic capability profile and innovation outcomes associated with these knowledge-based capabilities.

Across all three dynamic capabilities, the automotive industry performs better than the Malaysian industry aggregate. This positive position bears out in terms of the process and product-market development outcomes, which also perform higher than the Malaysian industry aggregate.

Figure 8.9: Dynamic Capability Profile of the Automotive Industry



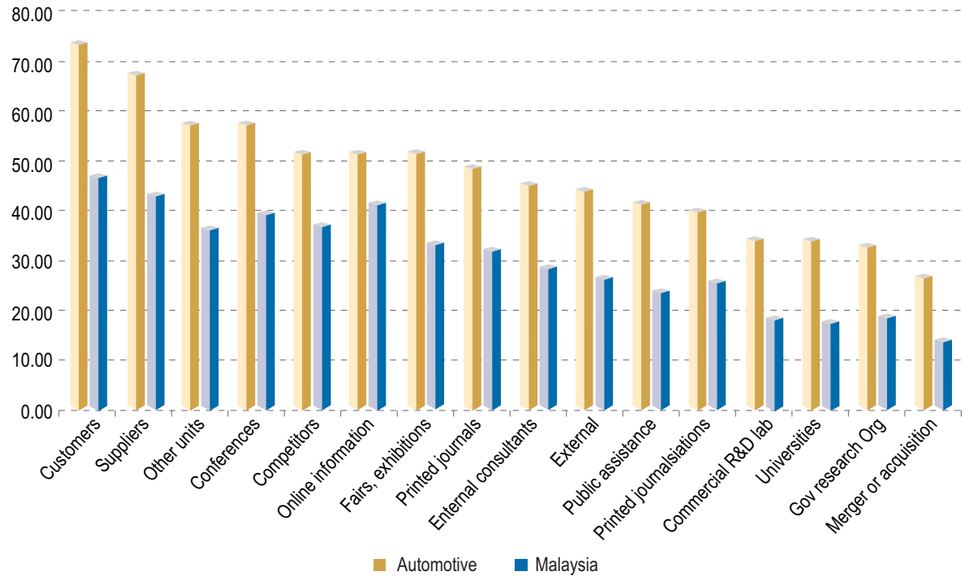
8.5.1 Absorptive Capability

Based on **Figure 8.10**, the automotive industry is active in collecting external information from its customers, and systematically handling and storing this information for future potential opportunities. The automotive industry also appears to be active in acquiring technology, creating learning around it and then using it. All of these factors come together to form a strong absorptive capability.

The automotive industry gets its information and knowledge from numerous sources (Figure 8.10). The top three sources of knowledge are customers, suppliers and knowledge from within the company itself. This suggests that the automotive industry is market-focused with customers being the main source of intelligence. Suppliers are the next most important source, and this is indicative of close links between companies and suppliers. Learning from internal units is also an important part of the automotive industry's knowledge capability building. Other major sources of knowledge absorption are conferences and competitor benchmarking.

In all instances, automotive industry firms source knowledge at a higher level than the Malaysian aggregate. The industry shows a healthy appetite for knowledge and explores a wide range of sources in near-equal measure, covering the whole spectrum from market sources to public institutions.

Figure 8.10: Sources of Knowledge in the Automotive Industry



8.5.2 Adaptive Capability

In order to ensure that firms are able to use knowledge inside the organisation, they must possess a high level of adaptive capability. Adaptive capability endows firms with a capacity to configure and reconfigure structures, people and resources that allow the use of knowledge to create specific outcomes desired by the organisation. In other words, it makes externally absorbed knowledge fit for use within the organisation through a process of making available the right blend of resources. The automotive industry shows very positive monetary and human investments in order to ensure that it is capable of responding to opportunities. Having strong adaptive capability allows automotive industry firms to rapidly make necessary adjustments in line with changes in the customer needs, competitive manoeuvres and technological shifts.

The skills profile of firms in the automotive industry is suggestive of a vibrant industry endowed with significant human capability. As **Figure 8.11** shows, business administration graduates constitute the largest group in the Malaysian automotive industry. Unsurprisingly, general engineering, and electrical and electronic engineering are the next two groups, followed by computer science, social science and other natural sciences. All of these feature at a higher level than the Malaysian aggregate. In much lower numbers are individuals with expertise in disciplines such as biotechnology.

The strong presence of science related expertise, especially engineering is unsurprising. Combining electrical and electronic with general engineering shows the automotive industry is dominated by an engineering skill base. Possessing adequate skills and expertise is fundamental in adaptive capability of the firm. The skills profile shows that the automotive industry is a strong industry with solid potential to rise up the value chain ladder, if appropriate strategies can be put in place to leverage on its human capability foundation.

Malaysia's institutional environment also plays a significant role in the building of capabilities of industry (**Figure 8.12**). Institutions in Malaysia, such as government agencies, industry association and universities, provide a range of assistance and support to firms in the automotive industry. Human capability building in the form of training, educational and skill enhancement actively takes place within the automotive industry. Firms also seek assistance from agencies to help them penetrate markets and take advantage of opportunities, while receiving help to improve operations capability through assistance on standards and quality management. Overall, the automotive industry appears to be highly receptive to advice and assistance across the full range of services available to them; this can be observed by each component scoring higher than the Malaysian aggregate.

Figure 8.11: Skills Profile of the Automotive Industry

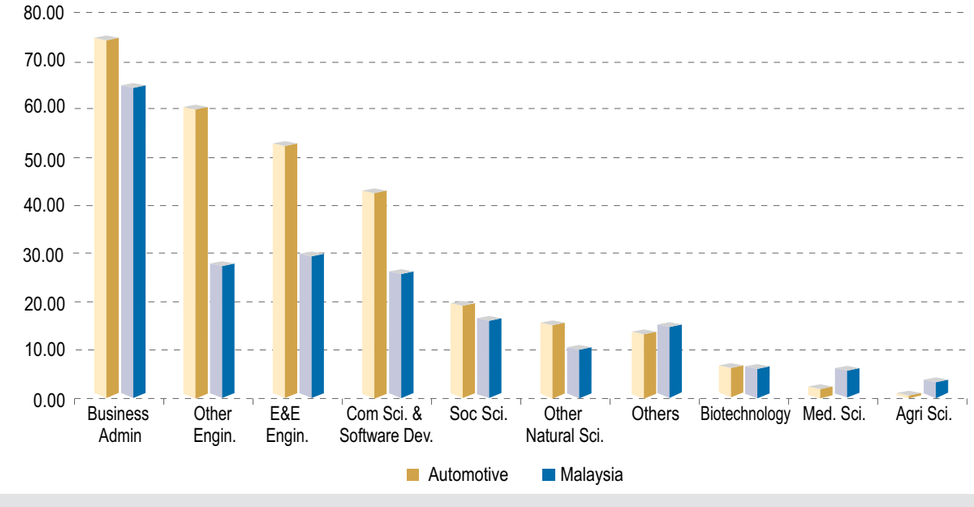
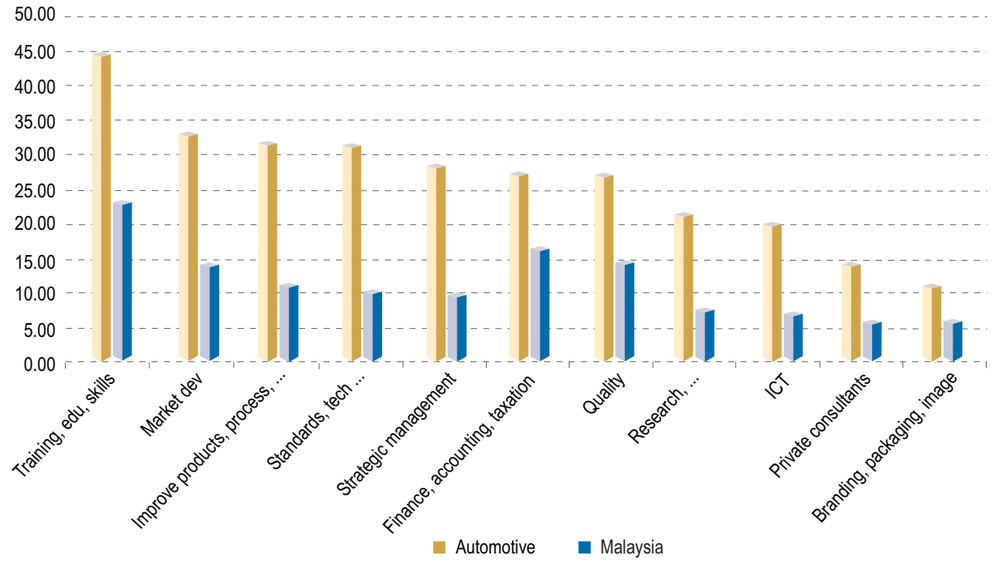


Figure 8.12: Role of Institutional Environment in Skill Building of the Automotive Industry



A similar pattern can be observed by the various categories of firms, irrespective of their size and local or foreign ownership. All seek significant assistance to develop human capability, penetrate the market, and build operational capability through assistance in process improvement and advice on standards.

8.5.3 Innovative Capability

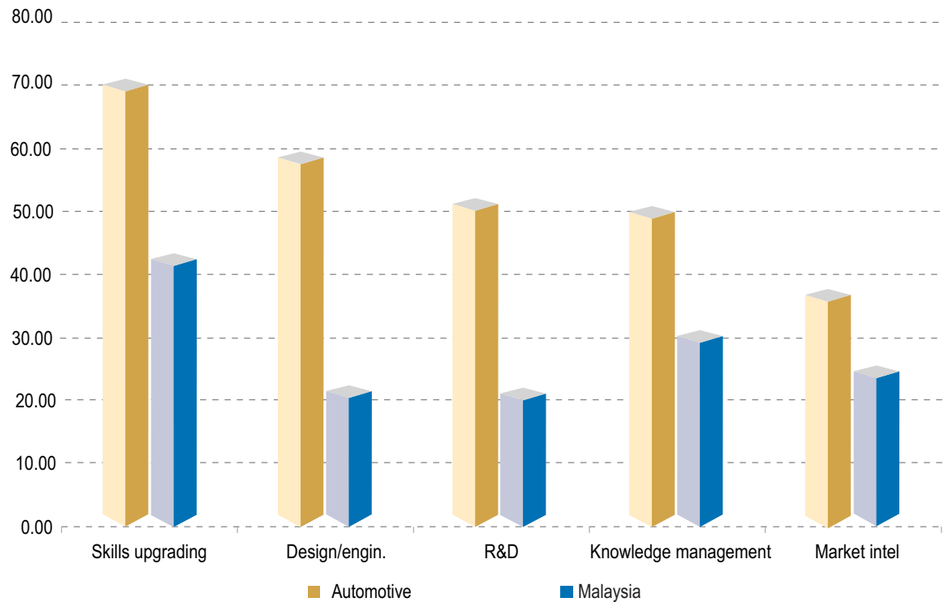
Investing in the development of market understanding and making resources available are by themselves insufficient to foster innovation. It is necessary to conceive and execute processes that deploy organisational resources to identify and act on opportunities. Firms that are able to bring external knowledge, assimilate it within their people and process it in a manner that allows them to create new products and innovations are highly capability. Firms in the automotive industry possess this ability to an adequate degree and hence are able to translate their absorptive and adaptive capabilities into firm level product and process outcomes.

Malaysian automotive industry firms show that they are engaged in a much higher level of innovative capability building activities, compared with the Malaysian aggregate. Automotive industry firms are more than twice as active as the Malaysian aggregate in terms of investment in R&D and design and engineering improvements, and 20% higher in management of knowledge. At the same time, they also show strong skill upgrading activity to enhance their adaptive capability, and high level focus on market intelligence to enhance their capability to develop products and services based on the needs of the market.

8.6 Outcomes of Dynamic Capabilities in the Automotive Industry

The market footprint of the Malaysian automotive industry shows it to be heavily domestic-orientated, with 80% of revenues originating from the home market. Of this, sales revenues within the state comprises 46%, indicating significant co-location or corridor influence. Breakdown of export sales shows the regional market (ASEAN plus Japan, China and South Korea) accounts for 13.3%, with international sales at only 7.30%. While the Malaysian automotive industry is gradually expanding its presence regionally, the mainstay of its output is directed at the home market.

Figure 8.13: Knowledge Intensive Activities in the Automotive Industry

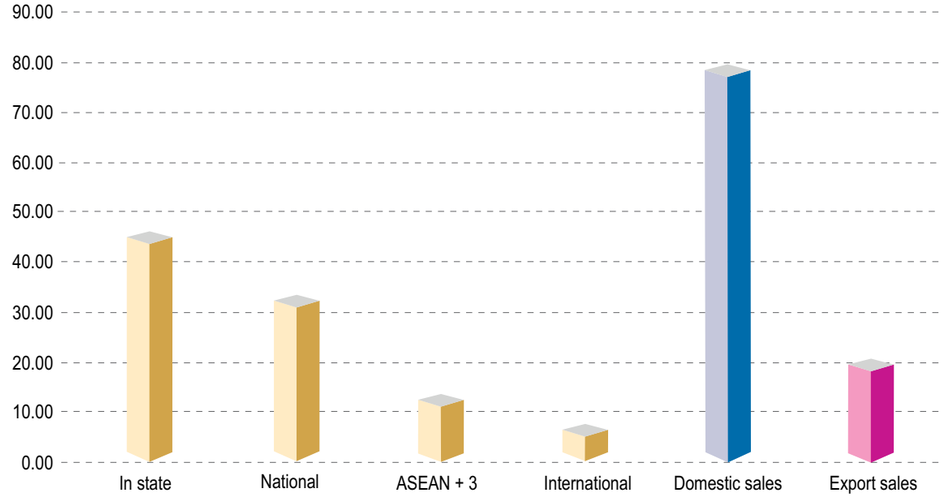


Foreign company operations in Malaysia show an even stronger focus on the Malaysian market. Large foreign companies get 85.5%, and the smaller foreign firms 89.4% of sales revenues from domestic sales. This suggests that foreign companies are primarily interested in penetrating the Malaysian consumer market rather than use it as a manufacturing hub for the region. In contrast, large local companies have a similar predisposition toward domestic markets but also have a comparatively stronger presence in the regional market with sales of 20.5% in ASEAN; by comparison, large foreign companies have 3.3%. Smaller local companies show a similar pattern to their large local counterparts, with 13.0% of sales revenue arising from regional markets.

Having laid sound knowledge foundations, automotive industry firms have taken significant steps to develop underlying capabilities for competitive success. The automotive industries' significant possession of the three dynamic capabilities has allowed the industry to create internal improvements, in terms of more efficient operations and better managed processes and control, which ultimately lead to higher quality and lowered costs of production. These firm-specific improvements are visible through higher levels of product sophistication and new product releases. Despite the positive outcomes, it is necessary to be cautious since the majority of Malaysian product developments are simply new-to--firm rather than new-to-world innovations. In others words, a large proportion of innovations are imitations and refinements of what already exists in leading markets or technology space.

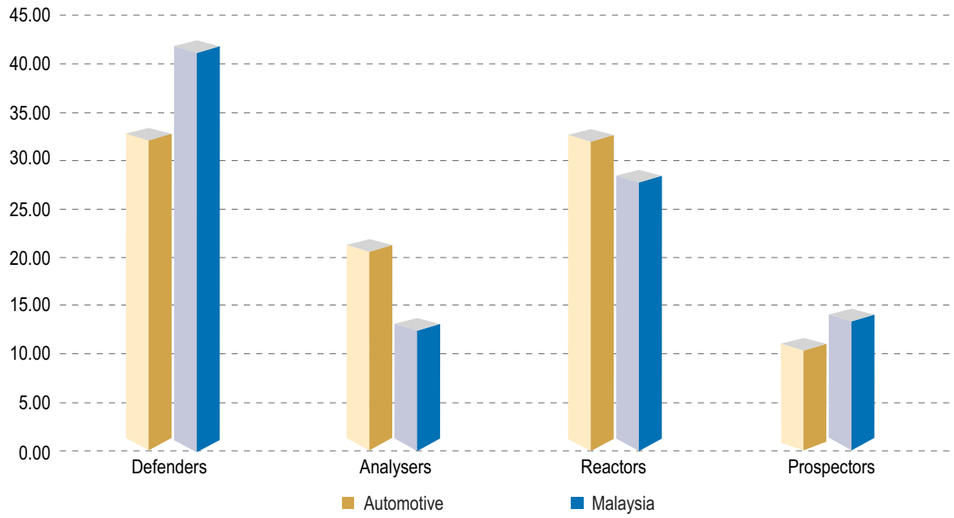
Nonetheless, despite competitive challenges, the automotive industry still managed heartening progress, with many of the firms in the industry developing significant armoury of dynamic capabilities for battle in an intensifying competitive space and an environment of high probability discontinuous shifts.

Figure 8.14: Market Presence of the Automotive Industry



Note: The results are based on survey data.

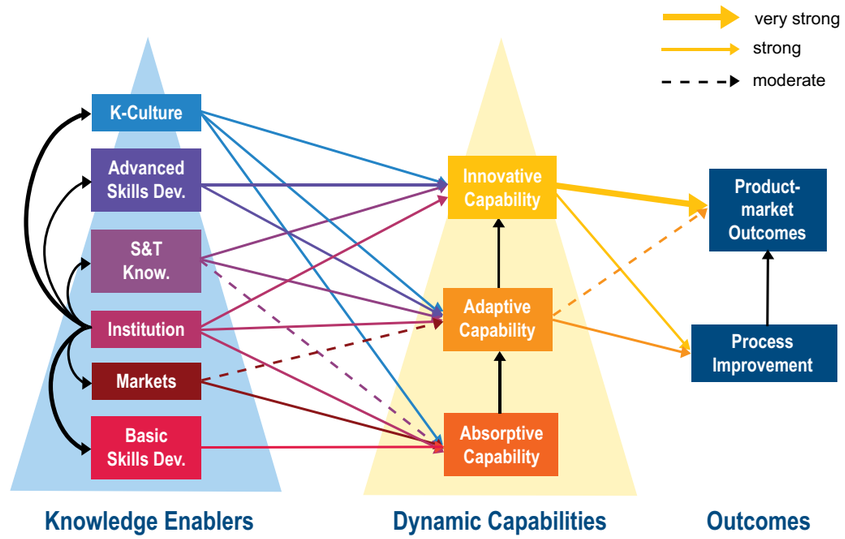
Figure 8.15: Strategic Profile of Firms in the Automotive Industry



The automotive industry firms' strategic profile suggests strong presence of companies that are Defenders (33.3%) and Reactors (33.3%). Defender companies focus their efforts in a select area and aim for quality in their products. In contrast, Reactor firms are those with a tendency not to adapt to changes in the marketplace and technological shifts, and only respond to change when their very existence is threatened. These two types of companies form the largest groups. Defenders feature at a lower level than the Malaysian aggregate, whereas Reactors are higher. The third group, Analysers are 21.7%, and the smallest group is represented by Prospector firms (11.6%). The automotive industry has more Analyser firms than the Malaysian aggregate. However, the percentage of Prospector firms in the industry is lower than the national aggregate.

The industry has a large number of Defender firms whose focus is not on innovation but on operational matters to improve their product service offerings. In addition, the industry is almost equally populated by Reactor firms, who are not market leaders but followers instead. In sharp contrast, Prospector firms are highly innovative companies that take risks by investing into potentially high pay-off products or services of the future. Such firms unfortunately are the smallest in number, even lower than Malaysian aggregate. This is indicative of weakness within the Malaysian automotive industry, since such firms are the front-runners of change and are the highest value-adders to the economy through their ability to create strong positive spill-over effects.

Figure 8.16 Knowledge Ecosystem of the Automotive Knowledge Ecosystem in an Advance Country



Note: Very strong impacts are represented by the bolded line, strong impacts are represented by normal lines and moderate impacts are represented by dotted lines.

8.7 Relationships between Key Blueprints of the Automotive Knowledge Ecosystem.

In this section, we investigate the impact of knowledge enablers on dynamic capabilities, followed by the economic outcomes for the automotive industry. Understanding the knowledge ecosystem for the automotive industry in Malaysia requires benchmarking the ecosystem in Malaysia with that of advanced sector countries (Germany, Japan, and United States). The content analysis and data obtained from DOS suggest that the automotive industry in Malaysia is a Pace-setter. In other words, the automotive industry is a complex sector characterised by a very high level of knowledge use and constant drive for innovation.

As an illustration, the knowledge ecosystem for the automotive industry in advanced sector countries is shown in **Figure 8.16**. From the figure, we see that the knowledge ecosystem for firms in the automotive industry in advanced sector countries supports all three components of the dynamic capability, which drive both product and process innovations. Firms in this setting have very strong absorbability capability, which allows the development of higher value-added innovation (i.e. adaptive capability). Also, the strong absorptive and adaptive capabilities that exist in advanced sector countries enable firms in this industry to go beyond the adaptive capability stage in the pursuit of building innovative capability, leading to the development of new process improvements and product outcomes that are globally competitive.

Figure 8.17 Knowledge Ecosystem of the Automotive Industry in Malaysia

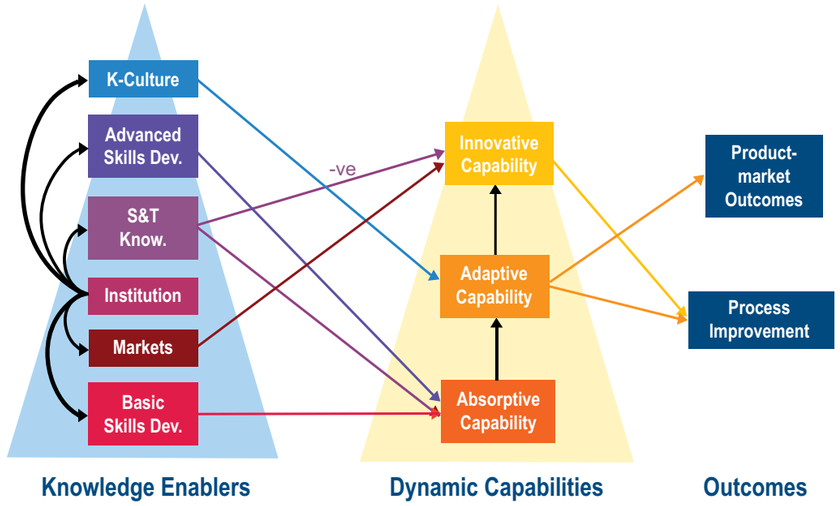


Figure 8.17 shows the knowledge ecosystem for the automotive industry in Malaysia derived from data obtained from DOS. The knowledge ecosystem for automotive firms in Malaysia is found to be relatively weaker than that of advanced sector countries. A notable difference between the ecosystem in advanced sector countries and Malaysia is the nature of impact of S&T knowledge on innovative capability. In advanced sector countries, S&T knowledge has a positive and significant impact on innovative capability. However, in Malaysia, S&T knowledge has a negative impact on innovative capability. Notwithstanding the strong skills development programme in the Malaysian automotive industry, the weakness in S&T areas when considered in conjunction with firm orientation towards R&D create an opportunity cost rather than a gain. This is likely to occur when investments are channelled to build S&T technical skills without taking into consideration lack of R&D activity within firms. Without substantive R&D activity, expertise, research personnel and S&T infrastructure for innovative capability, development goes to waste, as workers have little or no opportunity to leverage on their skills.

Figure 8.17 shows that though the knowledge ecosystem supports all three dynamic capability components in the Malaysian automotive industry, these capabilities typically enhance process improvements. Nonetheless, there is an impact from adaptive capability on product market outcomes. Without innovative capability diving product innovations, the adaptive capability's impact essentially involves releasing new products that are not necessarily cutting edge in their market domain.

The strength of the automotive knowledge ecosystems in advanced sector countries and in Malaysia is summarise d in **Table 8.1**. This table shows that the knowledge ecosystem for the Malaysian automotive industry is relatively weaker than that of advanced sector countries

Table 8.1: Knowledge Enablers and Dynamic Capabilities for the Automotive Industry

Advanced Countries	Malaysia
Basic skills have a **positive and strong impact** on absorptive capability. In advanced sector countries, the level of basic skills is high. Basic skills initiatives in these countries are primarily driven by government agencies, regulatory authorities, industry associations and institutions of learning.	Basic skills have a **positive and strong impact** on absorptive capability. In Malaysia, the critical role of government agencies and regulatory bodies, such as MITI, MIDA, MAI and SIRIS, ensures continuous upgrading of basic skills is taking place in the automotive industry.
Market intelligence has (1) a **positive and strong impact** on absorptive capability and (2) a positive and moderate impact on adaptive capability. In advanced sector countries, suppliers, customers, competitors, external consultants and commercial R&D centres contribute to the strong absorption of new knowledge, especially in the use of new technology, systems and processes, which are directed toward the development of new, and cost-efficient product and services for the automotive industry.	Market intelligence has a **positive and strong impact** on innovative capability only. In Malaysia, the automotive industry relies on suppliers, customers, competitors, external consultants and commercial R&D centres to undertake new innovations (mostly incremental innovations), where local talent is deployed to develop cost-efficient products and service, including the development of niche products and services related to hybrid and electric vehicle technology.
Institutions are **strong enablers** of the knowledge ecosystem and have a **direct strong and positive impact** on the three dynamic capabilities. In advanced sector countries, institutions such as regulatory authorities, trade associations, government research institutions and universities play a role beyond creating a vibrant automotive ecosystem. They drive the dynamic capabilities components directly. This includes skills development, upgrading of talent, and undertaking R&D development that will contribute to the next generation products and services for the automotive industry.	Institutions are **strong enablers** for the other knowledge enablers, but **do not produce any direct impact** on the three dynamic capability. In Malaysia, regulatory bodies responsible for oversight of the industry need to play a proactive role in the creation of an industrial ecosystem that is conducive to competitiveness enhancement. Industry associations and universities need to not just interact act with each other but must create the necessary highly trained talent, cutting edge R&D skills and collaborative networks for industry as exemplified by advanced sector countries. For example, Germany's Fraunhofer Institutes are active across the country in developing new technologies, the education system is world-class, and deploys a dual education system in which in-class theory are melded with on-the-job training to create a pool of flexible and highly skilled labour.

Table 8.1: Knowledge Enablers and Dynamic Capabilities for the Automotive Industry (cont'd)

Advanced Countries	Malaysia
S&T knowledge has (1) a **positive and moderate impact** on absorptive capability only, but (2) a positive and strong impact on both adaptive and innovative capabilities. In advanced sector countries, technology and scientific development are strongly encouraged through creation of recognition and rewards systems that provide a strong sense of professional pride to careers in science and engineering. Another feature of these countries is that they possess strategic programmes that allow them to tap into a broad spectrum of engineering and related expertise to build excellence and innovation in the automotive industry. By adopting an integrated multi-disciplinary research approach, it becomes possible to develop strong industrial cluster with the full complementarity of skills to strengthen and extend existing automotive product lines for the future needs of the global marketplace rather than just service current short term needs.	S&T knowledge has (1) a **positive and strong impact** on to absorptive capability, but (2) a negative and strong impact on innovative capability, which suggests that **S&T knowledge is an opportunity cost in the Malaysian setting.** In Malaysia, firms in the automotive industry are users of new technology and innovation. Most of the S&T knowledge is employed to improve the absorptive capacity. R&D within the industry is at an infant stage. Without sufficient R&D investments in high-end S&T, expenditure on the above can become opportunity cost rather than opportunity gains. Additionally, lack of expertise across the automotive industry supply chain spectrum as a consequence of a fragmented approach to STEM and social science and business-related areas hampers translation of local technology into new product design and development in the automotive industry.
Advanced skills have **a positive and strong impact** on dynamic capabilities related to adaptation and innovation. In advanced sector countries, significant resources are channelled to increase the quantum and quality of talent with higher degrees and industry-relevant knowledge. A carefully dovetailed 'quadruple-helix' enables automotive firms to configure theoretical knowledge and embed it into the production of real products for release into the global marketplace. This allows automotive firms in advanced sector countries to continuingly design and develop new automotive components, instruments, and models and technologies.	Advanced skills have **a positive and significant impact** on dynamic capabilities related to absorption only. In Malaysia, the level of quantum and quality of knowledge that exist in the automotive industry is progressing in an upward trend. However, there is insufficient collaboration and knowledge integration to create cutting edge breakthroughs. A weak 'quadruple-helix' hampers the flow of advanced skills to adaptive and innovative capabilities among automotive firms in Malaysia. This has led to a situation where automotive talent become users of new technology rather than inventors of cutting-edge innovations for the automotive industry.

Table 8.1: Knowledge Enablers and Dynamic Capabilities for the Automotive Industry (cont'd)

Advanced Countries	Malaysia
Knowledge culture has a **positive and strong impact** on the three dynamic capabilities. In advanced sector countries, the organisational culture of automotive firms is flat with a focus on outcome based key performance indicators. Leadership teams in firms often assume a TQM-type of approach to innovation: innovation responsibility is assigned to employees at all levels in the organisation (instead of a dedicated team). In addition, there is strong emphasis on multidisciplinary R&D approach to ensure that end market aspects, design, aesthetics, are seamlessly connected to the engineering and technological challenges of product development. Diversity in disciplines areas and expertise is valued for their input at different stages of product development. Development is future orientated by ensuring employees on the firms are well informed of the developing issues and trends in the global automotive industry. Creative approaches are encouraged through various approaches, ranging from TQM based continuous improvement to brain storming, fore-sighting and visioning. The nature of employment is highly competitive, but the automotive industry in advanced sector countries is able to offer career pathways that not only offer extrinsic rewards, but develop the individuals' innovative capability through the provision of environments that allow them to exercise their skills they are able to attract highest quality talent from abroad.	Knowledge culture has a **positive and strong impact** on adaptive capability only. In Malaysia, the organisation culture of firms is mostly hierarchical. R&D activities and responsibilities are primarily undertaken and assumed by a few people or a dedicated department. Many automotive firms do not invest sufficient resources on R&D activities. Instead, these firms tend to rely on advanced sector countries for new knowledge, innovation, and technology. The predominant knowledge culture in the automotive industry in Malaysia is to adapt and adjust existing automotive products and services for the local automotive market. Regulatory practices can also be barrier when local automotive industry need to comply with local created standards that at times are at odds or simply are a duplication of international standards. Rather than allow market dynamics drive the sector, there is overemphasis on a 'top-down' approach to drive change in the local automotive industry.

Table 8.1: Knowledge Enablers and Dynamic Capabilities for the Automotive Industry (cont'd)

Advanced Countries	Malaysia
The continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** In advanced sector countries R&D is coupled with ample availability of highly trained and skilled workforce with extensive experience at all requisite levels: basic, technical, and R&D. This makes the automotive industry resilient in absorbing new knowledge, and using this foundation to create advance capabilities in the form of adaptive and innovative capabilities. A long history of experience in these countries fuses with the expertise of highly skilled labour force creates an impetus for knowledge intensification that results in technological advances that can be deployed to improve processes as well as create new lines of automotive products and services.	The continuum from absorptive capability to adaptive capability to innovative capability **is present.** In Malaysia, the skilled workforce in the automotive industry is capable but the outlook that prevails in the sector is one of adopting new automotive-related knowledge produced by advanced sector countries. Refining and modifying knowledge in order to meet local demand is the major form of R&D activity that is observed. This incremental outlook to R&D means that a majority of innovations arising from the industry are cosmetic in nature rather than fundamental.

A comprehensive evaluation of the flows from dynamic capabilities to economic outcomes in advanced sector countries' and Malaysia's automotive industries is summarised in **Table 8.2**. In the study, the impact of dynamic capabilities on economic outcomes for the automotive industry in advanced sector countries and in Malaysia differs significantly. In particular, the adaptive capability of firms in the automotive industry in advanced sector countries has a positive and strong impact on process improvements and a positive and moderate impact on product market outcomes. Innovative capability has a positive and strong impact on process improvement and a very strong impact on product market outcomes.

Adaptive capability of firms in the automotive industry of Malaysia has a strong and positive impact on both process improvement and product market development, but their innovative capability only contributes to process improvements. The local automotive industry has been successful in gaining access to product and technical innovations from advanced sector countries through a range of agreements and then using these to create adapted products for the domestic market. With this approach, it has been difficult to penetrate markets with highly discerning and sophisticated consumers.

Table 8.2: Dynamic Capabilities and Economic Outcomes for the Automotive Industry

Advanced Countries	Malaysia
Adaptive capability has (1) a **positive and strong impact** on process improvement and (2) a positive and moderate impact on product market development. In advanced sector countries, automotive firms that are strong in adapting new technology and innovation do not only continuously improve existing automotive products and services, but also create new automotive technology and applications for the global automotive industry.	Adaptive capability has (1) a **positive and strong impac**t on process improvement and (2) a **positive and strong impact** on product market development. In Malaysia, the adaptive capability of automotive firms is predicated on existing knowledge from advanced sector countries, which is subsequently used in the development of niche automotive products and services that meet the demands in the local automotive market.
Innovative capability has (1) a **positive and strong impact** on process improvement and (2) a **positive and very strong impact** on product market outcomes. In advanced sector countries, strong innovative capability among automotive firms is powered by several factors, such as a solid S&T base, high R&D investment and existence of a strong quadruple-helix. This contributes to the emergence of new automotive models, instruments, technology, applications, products, and services that not only meet the needs of the domestic automotive market, but also the global automotive industry.	Innovative capability has (1) a **strong impact** on process improvement, but (2) **does not impact** product market outcomes. In Malaysia, the automotive industry adopts new technology, systems, processes and management tools from advanced sector countries. This adoption of knowledge, technology, and innovation is geared toward improving cost-efficiency and meeting domestic automotive market demand.
Process improvement creates a **positive and moderate impact** on product market outcomes. In advanced sector countries, a solid S&T base and an aptitude to translate research underlies process improvements that enhance product development in the automotive industry. By virtue of being simultaneously at the forefront of scientific and engineering advance and at the same time possessing an industry structure and workforce able to use this knowledge good effect across a wide spectrum of applications enables the auto-industry of advanced nations to be highly competitive in global arena.	Process improvement **does not impact** product market outcomes. In Malaysia, most process improvements in the automotive industry are derived from adaptions and usage of foreign technology, knowledge, and intellectual property, which limits the potential for creating new automotive market outcomes and intellectual property.

8.8 Summary: Key Trends, Challenges, Way Forward and Best Practices

8.8.1 Industry Trends

The automotive industry in Malaysia has a rich history. Starting from a humble beginning, this industry commenced as components-and-parts industry. The defining step for this industry is setting up domestic vehicle production capabilities. This spilled over into growth of an associated cluster of component and parts supplier firms to the automotive manufacturers. Players across the supply chain have developed significant strengths and capabilities over the past few decades, and now collectively constitute a major employer of skilled labour and contributor to the country's GDP.

A number of firms in the component industry have risen to be global players in their respective niches through a process of innovation and high quality production. However, the number of these world-class innovation success stories is limited. The mainstay of firms in the automotive industry is the domestic market. However, a good number of firms' existence seems to be dependent on heavy import tax duties and other protectionist measures. These companies have not been able to control costs through operational improvement of processes nor have they been able to produce highly innovative and valued products.

On a more positive note, companies in the automotive industry generally enhanced their competitiveness and responded to the intensified competition by instituting rigorous process control to reduce operational costs whilst conducting research and development to deliver customised products for the Malaysian market as a first step to international market expansion. A number of these firms exhibit strong dynamic capability profiles. For many companies, global ambitions are tempered by the sheer cutthroat nature of pricing as a consequence of excess capacity and underlying technological shifts. That makes the future highly uncertain, rendering the portfolio of R&D investments wide and beyond the reach of many Malaysian companies, aside from the largest of conglomerates. Firms with high dynamic capabilities are likely to be able to adjust but this is highly dependent on being able to keep pace with technological frontiers. For many companies this will mean having to locate specific niche areas in which they can keep abreast of the technology and then focus on better meeting specialist needs.

8.8.2 Challenges

The Malaysian automotive manufacturers are dominant players in the domestic market but are surrounded by a weaker components supply chain. Increasing income levels in the country and the region have opened new opportunities for local producers to increase their market share. However, the industry faces a number of challenges; and they are discussed below.

Institutions:

- Cooperation and collaboration between key stakeholders is patchy and weak.
- Educational institutions are not important drivers of R&D in the automotive industry – they function mostly as suppliers of low-level manpower.
- There has been significant historical investment in this sector and good progress has been made. Nevertheless, global competitiveness remains beyond the reach of local players, unless a concerted effort is made by institutions to create a strong globally viable ecosystem.

Basic Skills Development:

- Poor quantum and quality of TEVT competent workers for the auto industry.
- Industry needs are rapidly changing and the demand for highly specialised TEVT skills is very high. However, the quantum and quality of TEVT trained workers do not meet the needs of the industry.
- Training by industry players is limited due to high costs and a lack of expertise in the country.

Advanced Skills Development:

- Lack of talent with advanced knowledge and skill sets to handle the R&D complexities of the industry and make innovative breakthroughs.
- Available skills are useful to operate and use technology seamlessly, but are unable to produce new innovative products and processes.
- Talent with high advanced skills tend to be persuaded to work abroad – high brain drain of local talent to other centres of excellence in more developed countries.

S&T Knowledge:

- Application of S&T know-how is limited to technology use. Translation of know-how into new products and applications remains weak among local automakers and suppliers.
- Creative skills required to innovate are largely weak and underdeveloped.
- Recruitment of high calibre workers is difficult. Highly conducive R&D environments and lucrative remuneration packages overseas relative to Malaysia have hindered the flow of talent into the local industry.
- Lack of investment (or reluctance to invest) to improve S&T knowledge to deliver new innovation. Local firms focus on minimising costs rather than deliver new-to-the-world automotive products.

Market Intelligence:

- Local firms spread their risk through shift of responsibility throughout the automotive supply chain. Many neglect the importance of collaboration and networking among key stakeholders. This limits sharing and dissemination of knowledge and consequently limits development of innovative and high-end products.
- Lack of expertise and strong focus on cost efficiency across supply chain limits innovation of breakthrough products.
- Market presence of end products domestically and internationally is weak. This creates low level feedback and constrains opportunity for improvement.

Knowledge Culture:

- High dependency on foreign technology.
- Lack of ownership for R&D across the myriad departments and levels in the organisation.
- Lack of a conducive environment for innovation as a result of a predominant top-down approach in most automotive firms.
- Most SME players are risk averse – they are willing to 'cash-out' on their IPs/innovations by selling to bigger players or foreign MNCs.

8.8.3 Way Forward

As the country transitions from a production-based to a more knowledge-based high income economy, the Malaysian automotive industry is a growing market with increasing purchasing power. Increasing income levels in the ASEAN region also provides local automakers an opportunity to increase regional market share in the coming years. To strengthen their footprints and sustainability in the region, local automotive firms need to transform to enhance their global competitiveness. Below are some recommendations to help the automotive industry enhance their global competitiveness.

Recommendation 8.1: Move toward Automation Led Operational Efficiency

- Overhaul production plants by incorporating Industry 4.0 and use more robotics for repetitive tasks to improve quality and reduce costs.
- Redirect manpower to focus on delivering greater efficiency and innovation in products and applications.

Recommendation 8.2: Focus on Specialisation and Niche Markets

- Innovation should be focused on producing new and specialised products and applications (such as those related to electric and hybrid vehicles).

- Capitalising on niche markets (eco-friendly, compact & cheap automotive and parts) should help to build positions of strengths for enhancing competitiveness domestically and in the ASEAN region, i.e., cater to a wider segment of the regional population of 600 million where income levels are low through specialist niche focused strategy.

Recommendation 8.3: Foster A Robust and Vibrant Supply Chain for Risk Sharing and Collective Progress

Shift responsibility for the production of basic parts and supplies from OEM to component manufacturers in order to keep push cost pressures down and enhance production quality and efficiency.

Encourage greater collaboration and networking (such as multidisciplinary teams) among automotive players in the supply chain to enable collective relevance and progress. This can be done by allocating financial resources (grants) and access to state of the art research infrastructure and facilities for industry, government research institutes and university to undertake leading-edge research and development activities directed to the specific range of needs of the automotive industry.

Recommendation 8.4: Balance Market Protection with Competition to Invigorate Capability Building within the Local Industry

- Re-strategise market protection policies for the automotive industry to promote capability building for highly innovative automotive products. This can be done by providing tax incentives and other support services to leading international automakers that establish their R&D centres in Malaysia and have collaborative arrangements with local players with clear mechanisms in place for technology transfer and knowledge sharing.

- Provide subsidies to encourage purchase of local automobiles or parts. For example, 50% of all government purchases of automobiles, or parts produced by local operators or developed by international automakers, should contain a share of local materials or components.

Recommendation 8.5: Nurture Creative and Talented Workforce

- Intensify basic (TEVT) and continuous advanced training (leading to certification) that is academically and industrially inclusive through university-industry collaboration (curriculum design, course development, internships, work placements and HRDF programs).

- Establish large scale university-industry research and doctoral courses in the automotive-relevant areas (automotive engineering, design, and robotics engineering) in key research focus areas that will spawn the next generation automotive industry.

- Launch transnational research centres in Malaysia that work with leading global centres of excellence in the automobile industry.

8.8.4 Best Practices

Rapid technological advancements over the last decade have paved the way for extraordinary innovations in the automotive industry. The following best practices from leading automakers provide valuable insights on the types of policies and practices local automakers should consider to enhance their regional and global competitiveness.

Best Practice 8.1: Move toward Automation Led Operational Efficiency

Jidoka 'Automation' in Japan

- Jidoka translates to "automation practice with a human touch", where the process will detect process malfunction quickly, stop the production processes that are defective and alert the operators of the defect in the processes and systems.

- These practices reduce the cost of non-conformities and increase the speed of delivery, efficiency and quality of products.

Best Practice 8.2: Focus on Specialisation and Niche Markets

Tata Motors, India

- Tata Motors in India is widely regarded as one of the best modern day success stories in the automotive industry by innovating and delivering one of the most affordable and most energy efficient compact cars in the market to lure the world's burgeoning low and middle strata in developing countries class away from two-wheelers with a range of alternative power plants (compressed-air engine, electric vehicle, bi-fuel variant).

Best Practice 8.3: Foster a Robust and Vibrant Supply Chain for Risk Sharing and Collective Progress

Toyota Production System

- Toyota outsources the production of many of its component parts to independent component suppliers.

- A Kaizen (continuous improvement) mentality is adopted between Toyota and its independent component suppliers to ensure not only maximum quality and eliminate waste and improve efficiency, but also to produce new product-market innovations that will provide them with a superior competitive edge.

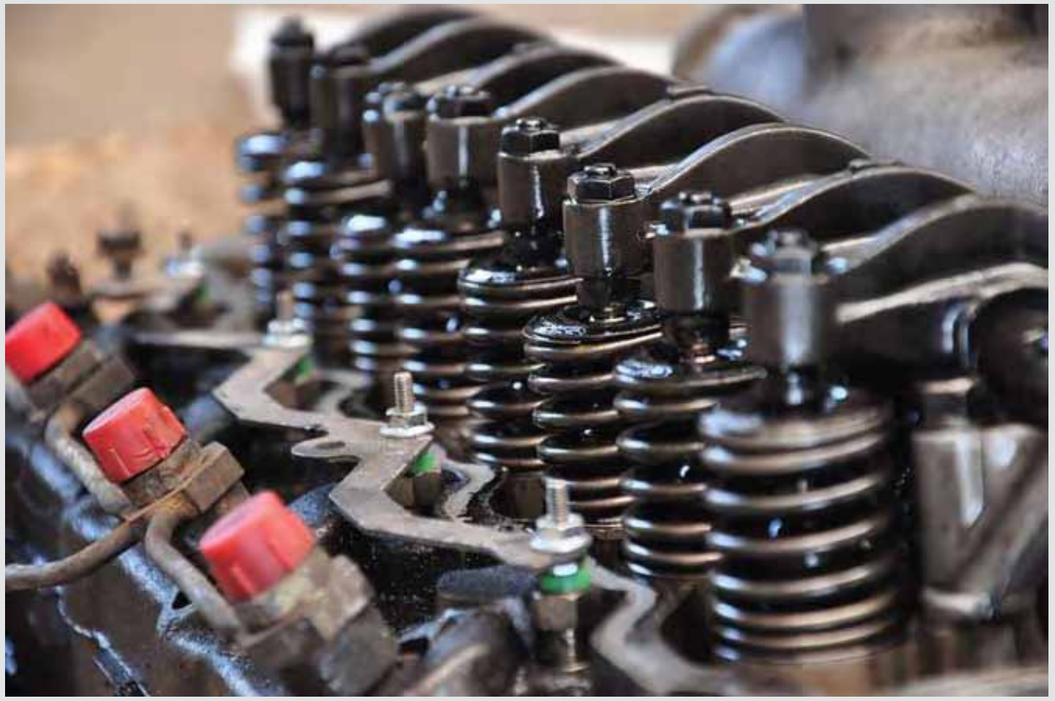
- Japanese component manufacturers who work with Toyota and adopt this system have reported great improvements in bringing employees and management together in the joint pursuit of improvements in innovation, productivity, quality, and working conditions.

Best Practice 8.4: Balance Market Protection with Competition to Invigorate Capability Building within the Local Industry

Support for Local New Energy Vehicles (NEV) in China

- The government provides a national subsidy of USD5,656-USD9,696 for NEVs for locally produced models from 2013 to 2020. This subsidy is also matched by some local governments. Further, the government removed a 10% purchase tax for local NEVs from 2014 to 2017.

- Local municipalities increased NEV infrastructure (charging stations, charging piles, power exchange centres and power distribution centres).



- At least 30% of all government vehicles are NEVs, produced by local players and foreign players operating in China. Foreign imports do not qualify for these incentives.

- Foreign ownership in NEV is encouraged, but restricted to a 50% ownership cap across the industry. This has led to Dongfeng-Nissan, Beijing-Hyundai and Shanghai-GM collaborations that have supported the development of the local NEV industry.

Best Practice 8.5: Nurture Creative and Talented Workforce

Fraunhofer Institutes in Germany

- 60 institutes focus in more than 250 areas of specialisations and are paired with universities with similar academic and research interests.

- Strong government-industry partnership and significant resources are channelled by federal and state government in partnership with industry to develop state-of-the-art research infrastructure, academic programs (undergraduate to post-doctoral training) and factory internship.

- Around one third R&D investment is to support firms with 250 and below employees. Fraunhofer also works with large, vertically integrated firms such as Daimler-Benz and Volkswagen on larger research projects.

- The institutes have a global reach. The institute has established 7 institutes in USA and several nodes in Austria, Chile, Italy and Portugal – these institutes are very knowledgeable of the local and international innovation ecosystems.

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CHAPTER 10

KNOWLEDGE CONTENT OF THE TEXTILE, WEARING, APPAREL AND FOOTWEAR INDUSTRY

CHAPTER 10
Knowledge Content of the Textile, Wearing, Apparel and Footwear Industry

10.0 Introduction

The Malaysian textiles, wearing, apparel and footwear (TWAF) industry is mature, characterised by low barriers to entry as well as an intensely competitive (and hence price-sensitive) environment. This sector is heavily dependent on a good mix of technically skilled and unskilled labour. The majority of firms in the industry are SMEs.

Textiles, Wearing and Apparel

The Malaysian textile, wearing and apparel industry began en vogue in the 1950s as small family businesses catering to the local communities. From the manufacturing of rudimentary apparel like underwear and t-shirts, the textile, wearing and apparel industry today has broadened its portfolio to include much more sophisticated products like spinning, knitting, weaving, dyeing and printing, silk screen, embroidery and garment-making.

It is now a major industry with an export value of RM12.63 billion in 2015 and is the tenth largest earner in Malaysian exports, accounting for 2% share of Malaysia's total manufactured goods (MATRADE, 2016a). RM7.02 billion (55.6%) of the export value comes from textiles, while apparel only accounts for RM5.6 billion (44%) (MATRADE, 2016a). The second Malaysia Plan (1971-1975) marked the beginning of Malaysia's push toward export oriented industrialisation which led to the establishment of the textiles and apparel factories. The past 40 years have witnessed the growth of Malaysia's global reputation as a reliable producer of quality textile and apparel products.

Competition from low production cost countries such as China, Indonesia, Vietnam, Pakistan, Sri Lanka and Bangladesh has negatively affected the Malaysian industry. However, this has also spurred Malaysian manufacturers to push up the value chain by developing and improving processes, focusing on higher value-added products and improving efficiency through automation. Malaysian manufacturers are now focusing on building core competencies in dyeing, printing and finishing technologies. They have also turned their attention to high-value fashion apparel and technical textiles with specific practical attributes, such as geo textile for construction and heavy industries, flame retardant, antibacterial, antistatic, oil and water repellent, breathable and abrasion/tear/puncture resistant fabrics.

Importers of Malaysian textiles, wearing and apparels are confident of their capability to manufacture technically complex designs and international brands (e.g., Nike would contract their more complex garments to Malaysian manufacturers). The industry is heavily reliant on original equipment manufacturers (OEM), although Malaysia can boast of its very own successful apparel brand, Padini, which is making an impact in the international scene. Padini is an example of a manufacturing company which was able to move up the value chain to create its own original brand manufacturer (OBM).

The traditional batik industry is not performing well, with a declining number of designers and manufacturers. The government is making an attempt to revive the industry with the assistance of the Textile Manufacturers Association (MTMA). Efforts are required to promote batik among the younger generation, as batik could latch onto the current popular trend of modernising the traditional outfits. Potential also exists for Malaysia to enter the Islamic garments and headdress submarket using contemporary prints and colours, which is at present mainly imported from the Middle East (Euromonitor International, 2015). In addition, the Global Innovation and Entrepreneurship Foundation's (GIEF) founder and chairman, Datuk Ghazi Sheikh Ramli, believes that the batik industry should go eco-friendly. "Bamboo can turn batik industry green. You can use bamboo to make textile or fabric and paint batik designs on them. Eco-fashion is going to be very big in future" (Narayanan, 2014).

Although the textile, wearing and apparel industry is not part of Malaysia's NKEA, the government recognises the importance of improving manufacturing processes and its contribution to the economy. Hence, the government is providing manufacturers with an automation capital allowance of 200% on the first RM4 million expenditure incurred between 2015 and 2017.

Footwear

The Malaysian footwear industry is one of the oldest manufacturing activities in the country and is ranked 19th worldwide in export of shoes. According to MATRADE (2016b), the footwear industry is ranked 13th largest in Asia with a yearly production capacity of 70 million pairs. Similar to textiles, wearing and apparel, most of the footwear manufacturers are SMEs and cottage industries, using labour-intensive methods. In 2011, Malaysian Investment Development Authority (MIDA) recorded that there are about 1000 footwear manufacturers producing about 70 million pairs of shoes for both the export and domestic market. Most of factories are located in Perak, Selangor and Johor. Around 10% of the footwear manufacturers are located in Seri Kembangan, a suburb 50km from Kuala Lumpur.

While most comprise backyard operations, there is a number of well-equipped, large-scale manufacturers operated by MNCs. Malaysia is renowned for its designer, value-for-money, high quality footwear, particularly safety and industrial footwear. Similar to textiles and apparels, Malaysian footwear manufacturers mostly manufacture under licence for international brands although there are some which have moved on to OBM to market their own brands. Malaysia competes in a region of giant footwear manufacturers – Asia, where 85% of the trade is concentrated in China, India and Central and SE

Asia. Instead of competing head-to-head on prices with countries like China which has lower costs of production, Malaysia is focusing on well-designed and superior quality footwear. The footwear industry is performing reasonably well, with exports increasing by 6.8% in 2013 from RM443.8 million to RM474.1 million in 2014, a positive growth of 7.6% was also recorded for January to May 2014 (New Sabah Times English, 2014). In 2015, Malaysian's exports of footwear rose by 4% to RM 493.1 million (MATRADE, 2016b). The top five countries to which Malaysia exports footwear in 2015 are Peru, Mauritius, Finland, Iceland and Sweden (World Integrated Trade Solution, 2016).

10.1 Key Developments and Initiatives

The TWAF industry has gone through major changes over the years and these changes are due to several factors, which are outlined below:

Multifibre Arrangement (MFA) in 2005. The phasing-out of the MFA arrangement accelerated the industry's move to improve efficiencies in production, to improve speed and to lower cost in the face of increasing competition caused by the removal of the quota system. This led to global competition among production countries, in particular China, whose export to the West increased a hundred fold with the phase out in 2005. While the MFA phase out opens up more markets in the European Union and North America, it also exposes Malaysian textile, wearing, apparel and footwear firms to intense competition from countries that can produce similar textiles, wearing, apparel and footwear at a much cheaper price.

Third Industrial Master Plan (IMP3). Textiles and apparel is one of the 12 industries in the manufacturing industry targeted for further development and promotion through to 2020. The industry was selected because of its potential to contribute to the nation's economic growth. The TWAF industry was the ninth largest export earner in 2013, with a value of RM10.3 billion accounting for 1.4 percent of the Malaysia's total exports of manufactured goods (MIDA, 2015).

Ridding On the Global Environmental Sustainability Trend – Ethical Clothing. Companies in the textile, wearing, apparel and footwear industry are following the global trend toward sustainability and environmental awareness by introducing clothing made of organic materials, such as bamboo, and/or sustainable methods of production. Global Organic Textile Standard (GOTS) –compliant brands are gaining considerable market traction. Nukleus, for example, sold in more than 140 independent and chain stores and 17 online stores across Malaysia, Singapore, Thailand, Indonesia, Taiwan and Australia.

Automation Capital Allowance (2015-2017). This capital allowance to increase automation in labour-intensive industries under the 2015 Malaysian budget provides a much needed boost to encourage the textile, wearing, apparel and footwear industry to modernise their manufacturing process. Moreover, this one-off incentive is open to high labour-intensive industries such as rubber products, plastics, wood, furniture and textiles. The incentive includes a 200% capital allowance for undertaking automation on the first RM4 million expenditure incurred from 2015 up to 2017.

Liberalisation of Trade. The establishment of ASEAN as a single market under the ASEAN Economic Community's free-trade pact (AEC) in 2015, aims to help stimulate growth in the manufacturing industry with greater access to intra-regional and global trade. ASEAN is growing as a region of low-cost manufacturers and as an export destination. Although ASEAN is now China's biggest competitor, it is also one of China's most important trading partners.

Other than stimulating growth and increasing competition among the regional players, the relaxation of trade and investment conditions with the setting up of AEC may make it easier for Malaysian companies to relocate their manufacturing plants to other ASEAN countries with a cheaper cost of labour, for example, Cambodia and Vietnam.

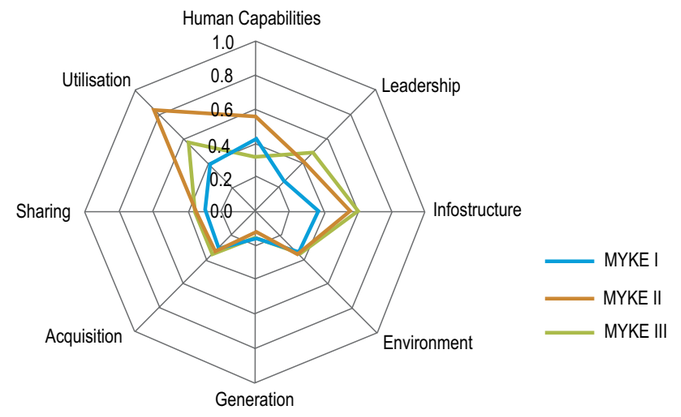
10.2 Knowledge Content

Figure 10.1 shows the knowledge resource foundations for the textile, wearing, apparel and footwear industry over the three MYKE assessment periods in 2003, 2007 and 2014. Overall, the figure shows that the industry experienced a healthy improvement in most of its knowledge resources from 2003 to 2007, but was unable to maintain its trajectory until 2014. This is particularly evident for knowledge utilisation and human capabilities. This trend appears to be similar for other mature industries, such as rubber and plastic, and construction. The picture painted here suggest a mature industry with relatively low innovation and R&D, and reflective of what industry players termed "sunset industry". Other indicators (besides knowledge utilisation and human capabilities) which highlight this include its low level of knowledge leadership and infostructure.

Next, we examine each of the elements of knowledge enablers and knowledge action to understand the contribution of these elements to the current knowledge resource foundation of the TWAF industry.

Figure 10.1: Overview of Knowledge Enablers and Knowledge Actions for MYKE I, MYKE II and MYKE III

Textile, Apparel & Footwear



10.3 Knowledge Enablers

10.3.1 Human Capabilities

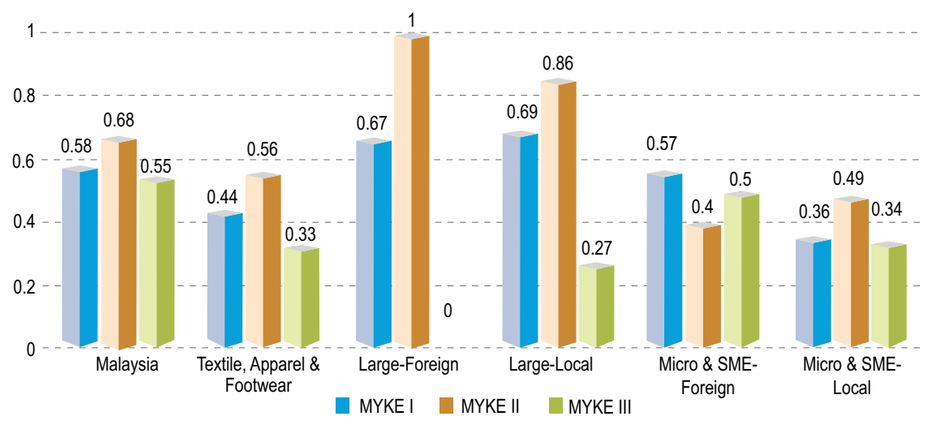
The results highlight the ability of the textile, wearing, apparel and footwear industry to attract technically skilled talent is relatively poorer than other industries. The human capability index for TWAF industry is lower than the Malaysian aggregate across all three MYKE assessment periods (0.44 in 2003, improving to 0.56 in 2007, but declining sharply to 0.33 in 2014). The major contributor to this decline are the large foreign firms, which improved from 0.67 in MYKE I to a perfect score of 1 in MYKE II period, but plunged to 0 (zero) in MYKE III. Large local firms also experienced a similar decline (although not as drastic as their foreign counterparts) increasing from 0.69 in MYKE I to 0.86 in MYKE II but declining sharply to 0.27 in MYKE III. The small firms, whether foreign or local performed better than the large firms in 2014, although the local SMEs also registered a decline in their ability to attract skilled talent.

This industry appears to be unable to attract highly skilled talent, in particular the large firms. It may be due to the limited technically advanced processes required to manufacture textile, wearing, apparel and footwear since most of the companies are OEM and reliant on cheap labour. Perhaps most of the technically-advanced processes controlled by large

foreign companies have shifted their operations out of Malaysia.

Overall, the trend in human capabilities in the TWAF industry is reflective of a manufacturing industry where the working environment is not as attractive as that in other industries, such as e.g., tourism and retail.

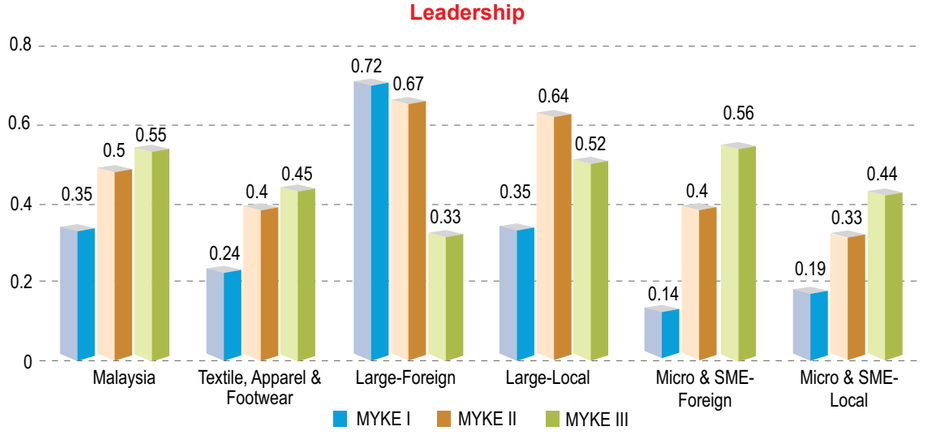
Figure 10.2: Human Capability of the Textile, Wearing, Apparel and Footwear Industry



10.3.2 Knowledge Systems and Leadership

The TWAF industry is falling behind Malaysia in terms of its knowledge leadership across all three MYKE assessment periods with index of 0.24 in 2003, 0.4 in 2007, and a minor improvement to 0.45 in 2014. The large firms, whether local or foreign, regressed in knowledge leadership. However, it is the large foreign firms which registered a progressive decline over the three (3) MYKE periods from 0.72 in 2003 to 0.67 in 2007 and 0.33 in 2014, while the large local firms started from a low base of 0.35 in 2003, improved to 0.64 in 2007 but declined to 0.52 in 2014. It is interesting to note that the large foreign firms in the TWAF industry had the lowest index compared to all the other firms in the MYKE III assessment period. This merits concern because one would expect large foreign firms to contribute to the Malaysian economy and the industry specifically in knowledge leadership. In contrast, the SMEs, both local and foreign are showing very positive increments in their knowledge leadership over the three MYKE assessment periods.

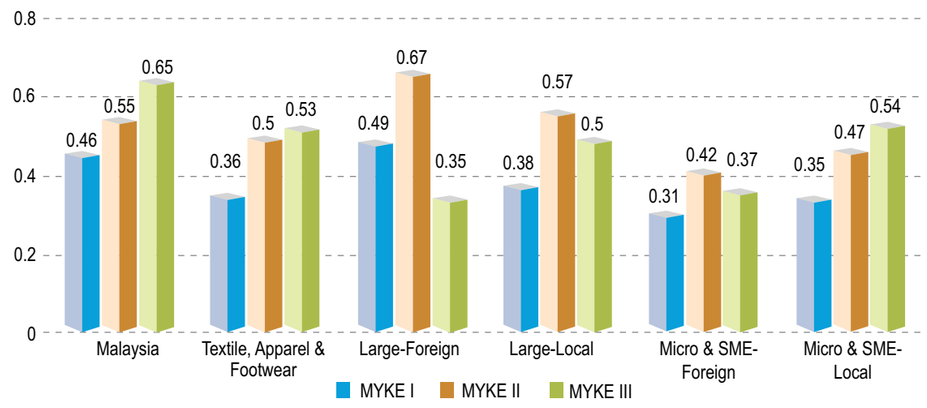
Figure 10.3: Knowledge Leadership in the Textile, Wearing, Apparel and Footwear Industry



10.3.3 Technology and Infostructure

There is a very slight improvement in technology and infostructure in the textile, wearing, apparel and footwear industry across the three MYKE assessment periods (0.36 to 0.5 to 0.53) and these indicators are below the national aggregate. There appears to be little push for technology and infostructure, likely because the industry is still reliant on manual labour. All firms, except for the local SMEs, registered an improvement in the MYKE II period from MYKE I, but fell in the MYKE III assessment period. This is unlike the Malaysian industry aggregate, which registered positive, incremental improvement across the MYKE assessment periods. Attention should be paid to the local small firms which show a very positive trend (0.35 to 0.47 to 0.54) – these SMEs have taken on the challenge to move their businesses into the 21st century and to keep up with the intense competition by upgrading their technological systems and computers, and they have more than caught up with the bigger players in leading the development of technology and infostructure.

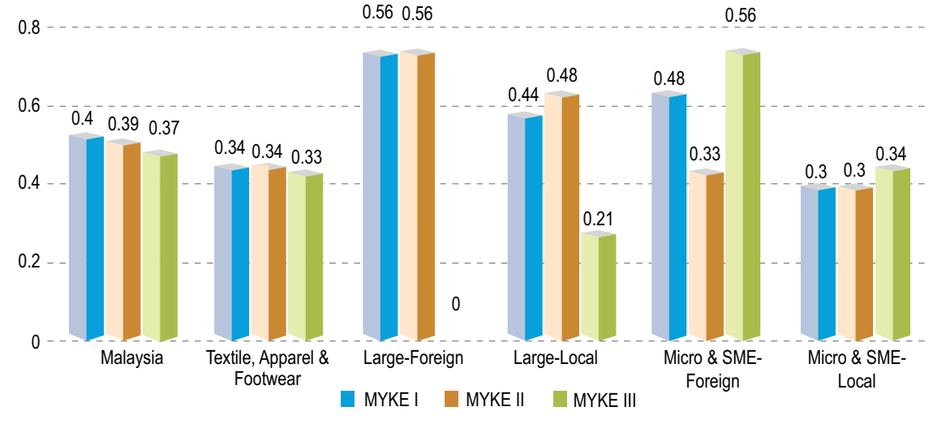
Figure 10.4: Technology and Infostructure of the Textile, Wearing, Apparel and Footwear Industry



10.3.4 Knowledge Environment

Similar to the other knowledge enabler dimensions, textile, wearing, apparel and footwear industry fell behind the Malaysian aggregate in engaging with the knowledge environment – the industry does not appear to be very active in its engagement with government and universities. In fact, there is no improvement at 0.34 for both assessment periods MYKE I and MYKE II, and declining very slightly to 0.33 in MYKE III. It is interesting to note that large foreign firms are not participating at all in the knowledge environment – results show a sharp decline from 0.56 in both MYKE I and MYKE II assessment periods to 0 (zero) in the latest assessment period in 2014. Again, similar to the observation under infostructure, the small firms seem to be leading the pack in engaging with government, universities and industry.

Figure 10.5: General Environment Awareness of the Textile, Wearing, Apparel and Footwear Industry

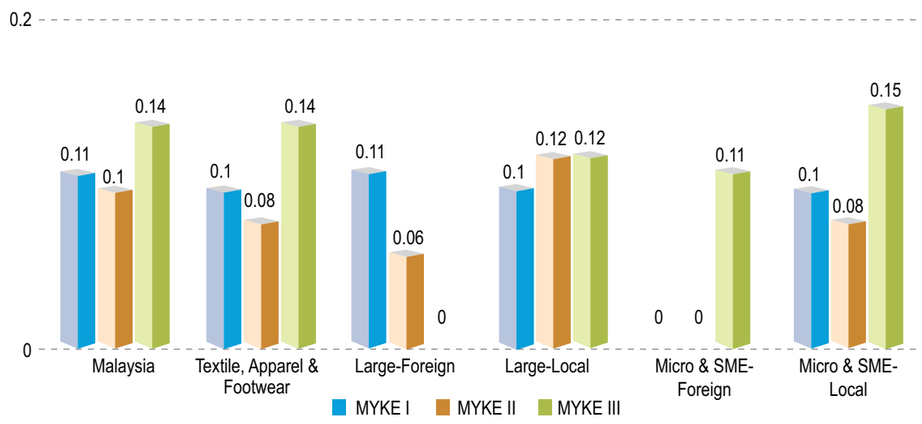


10.4 Knowledge Actions

10.4.1 Knowledge Generation

Knowledge generation in the TWAF industry is at a similar low level with the rest of Malaysia, with minor improvements over the three MYKE assessment periods (0.1 to 0.08 to 0.14). The results show the large foreign firms have continued to decline in their knowledge generation activities over the three assessment periods from 0.11 to 0.06 to 0 (zero), while the large local firms stagnated at 0.12. Again, it is the small firms, both local and foreign, which are taking the lead in R&D – knowledge generation activities are at a much better level for local SMEs than any of the other firms in the industry.

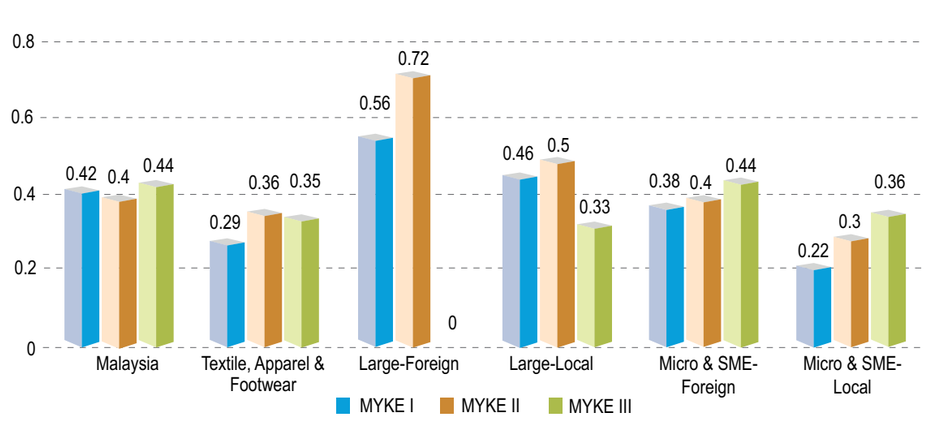
Figure 10.6: Knowledge Generation Activity in the Textile, Wearing, Apparel and Footwear Industry



10.4.2 Knowledge Sharing

Overall, knowledge sharing in the TWAF industry is at a lower level than the Malaysian aggregate across all three assessment periods (0.29 to 0.36 to 0.35). This little improvement shown in knowledge sharing activities among the industry players is reflected across the other knowledge action and enabler dimensions. An examination of the firms which contribute to this feature show that large foreign firms are the major contributors to the low index – from an index of 0.56, large foreign firms' index improved significantly to 0.72 during the MYKE II assessment period, but fell to zero in 2014. It appears that large foreign firms have decided to pull out of the knowledge economy all together (judging from the other knowledge resource dimensions). Unfortunately, the large local firms, while not at zero level, have also reduced their knowledge sharing activity. Again, it is the small firms, both local and foreign, which are more willing to share in the knowledge economy.

Figure 10.7: Knowledge Sharing Activity of the Textile, Wearing, Apparel and Footwear Industry



10.4.3 Knowledge Utilisation

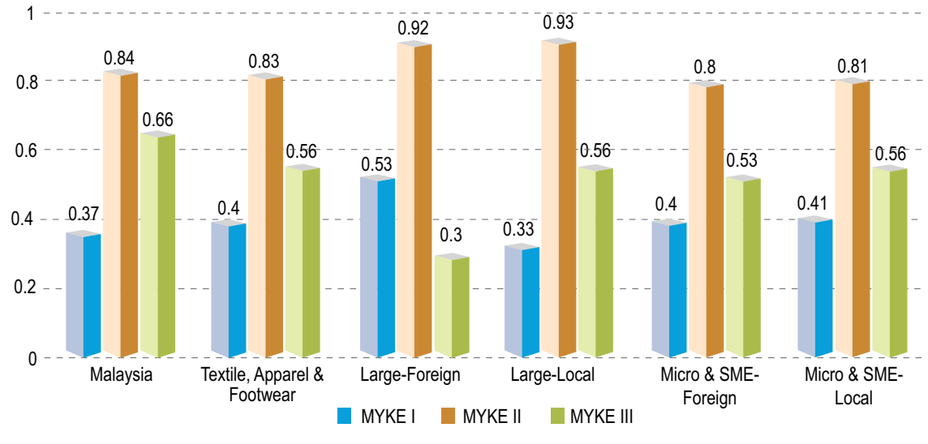
Knowledge utilisation in the TWAF industry follows a similar trend to the Malaysian aggregate – starting from a relatively low base of 0.4 in 2003, it quickly progressed to 0.83 in 2007, but fell quite sharply to 0.56. The end result was below the Malaysian aggregate. All firms, regardless of type, rose and fell sharply over the three MYKE periods. Following the other knowledge resource dimensions, large foreign firms showed the sharpest rise and drop over the three MYKE periods. In 2014, large foreign firms fell to a third in 2014 (0.3) from a near perfect score in 2007 (0.92).

The knowledge resource foundations over the three MYKE assessment periods show the trajectory of the industry's progress towards improving its knowledge and innovation. From the in-depth analysis of each dimension of the knowledge resources, one observes that the TWAF industry performed relatively well from MYKE I to MYKE II but was unable to sustain its momentum in MYKE III.

One could surmise that the poor improvement in infostructure, knowledge leadership and in particular the inability to attract talented human capital is indicative of an industry which is very mature, and because of intense price competition, is focused on driving down cost rather than investing in innovation and building human capabilities.

It is interesting to note the lead role played by small local firms in this industry in driving the knowledge economy and at the same time, the retraction of the large foreign firms in Malaysia's textile, wearing, apparel and footwear knowledge economy. This disparity may be indicative of the latter's reluctance to generate and share knowledge in Malaysia for fear of copying and brand counterfeiting. Local SMEs are realising the importance of improving and upgrading their manufacturing processes and are making attempts to improve their knowledge resources. Progress may be slow is in the right direction. The government should continue to provide incentives to encourage SMEs in the textile, wearing, apparel and footwear industry in its quest to reverse the image of sunset industry.

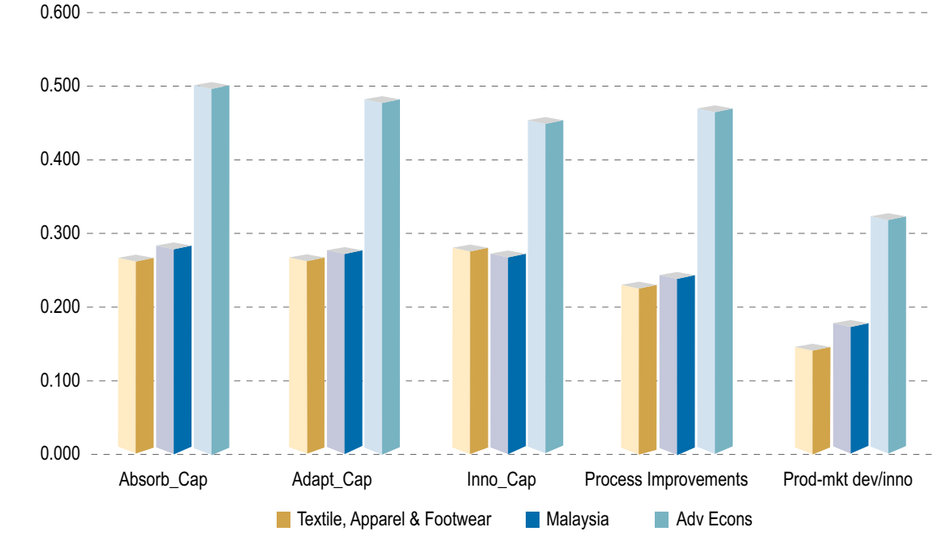
Figure 10.8: Knowledge Utilisation Activity of the Textile, Wearing, Apparel and Footwear Industry



10.5 Dynamic Capabilities Profile for Textile, Wearing, Apparel and Footwear Industry

The dynamic capabilities profile of the textile, wearing, apparel and footwear industry depicted in **Figure 10.9** suggests that firms in this industry may experience some difficulties in adapting to the competitive pressure and changes in the external environment. This is demonstrated by the moderate levels of dynamic capabilities in two components of dynamic capabilities (absorptive and adaptive), which is below the national aggregate. The only dynamic capability which is higher than the Malaysian industry aggregate is innovative capability indicating that the industry does well in utilising their existing market knowledge and technological capability in the development of improved new products and processes. However, this one positive dynamic capability may be insufficient to assist the industry in responding to competition and adapting to changes in the marketplace. This is indicated by the unsatisfactory outcomes for both process improvements and product-market development, which are below the national aggregate.

Figure 10.9 Dynamic Capabilities Profile of the Textile, Wearing, Apparel and Footwear Industry



10.5.1 Absorptive Capability

Figure 10.9 shows that the TWAF industry is only moderately active in acquiring and storing market and technology information for future opportunities. The results suggest the textile, wearing, apparel and footwear industry is relatively passive in building a rich knowledge base.

The top three sources of information are customers, suppliers and competitors, but even these top three sources are not significantly utilised to understand market changes or customer needs **(Figure 10.10**). There is very little knowledge sourced from R&D, universities, conferences or printed journals or technical reports, suggesting little interest in new technological advances and innovations. Instead the reliance on customers, suppliers and benchmarking of competitors suggests some vigilance to ensure that the products manufactured meet the needs of the marketplace.

10.5.2 Adaptive Capability

A high level of adaptive capability is necessary to enable firms to utilise external knowledge. Adaptive capability allows the firms to easily adjust and adapt their structures, processes and people to turn absorbed knowledge from external sources into useful knowledge for the organisation. The textile, wearing, apparel and footwear industry is only investing a minimum amount of resources in building its adaptive capabilities, thus it may be limited in its ability to respond rapidly to technological shifts and changes in the competitive and market landscape.

The skills profile in **Figure 10.11** paints a grim picture of the human capability in textile, wearing, apparel and footwear industry, with every skill below the national aggregate. Business administration makes up the largest group, but is still at a lower level than the national aggregate. The profile suggests that it is not able to attract highly skilled talent into an industry which is perceived as unexciting. Adaptive capability requires adequate skills and expertise not present in the textile, wearing, apparel and footwear industry.

Figure 10.10: Sources of Knowledge in the Textile, Wearing, Apparel and Footwear Industry

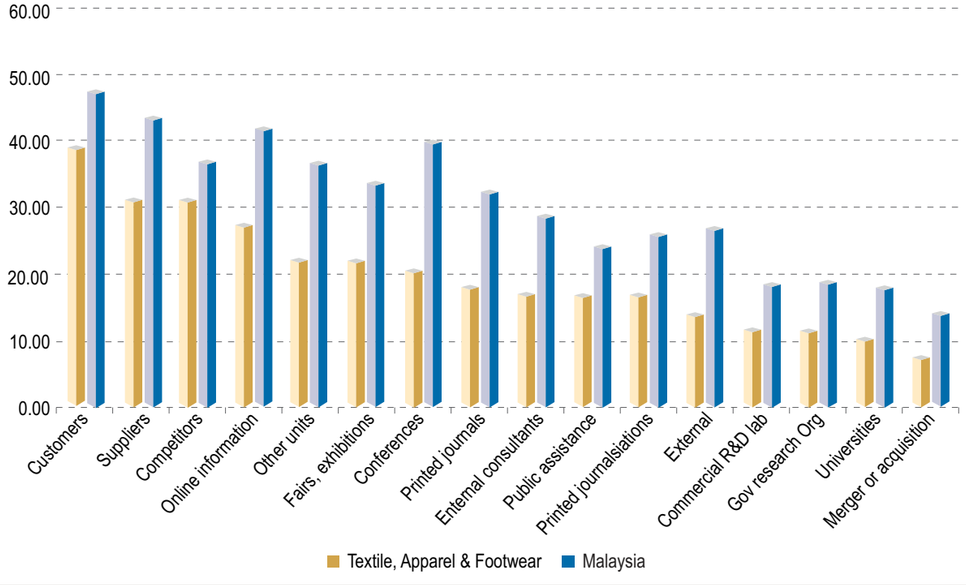


Figure 10.11 Skills Profile of the Textile, Wearing, Apparel and Footwear Industry

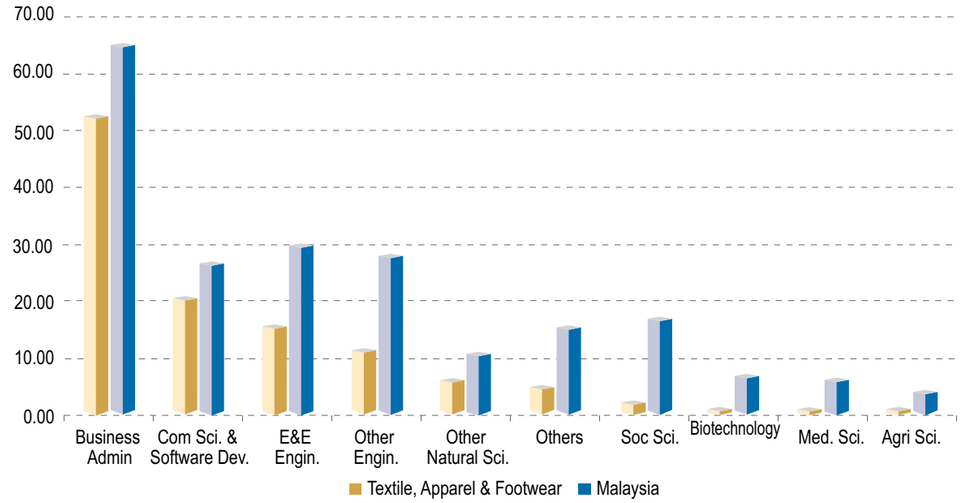
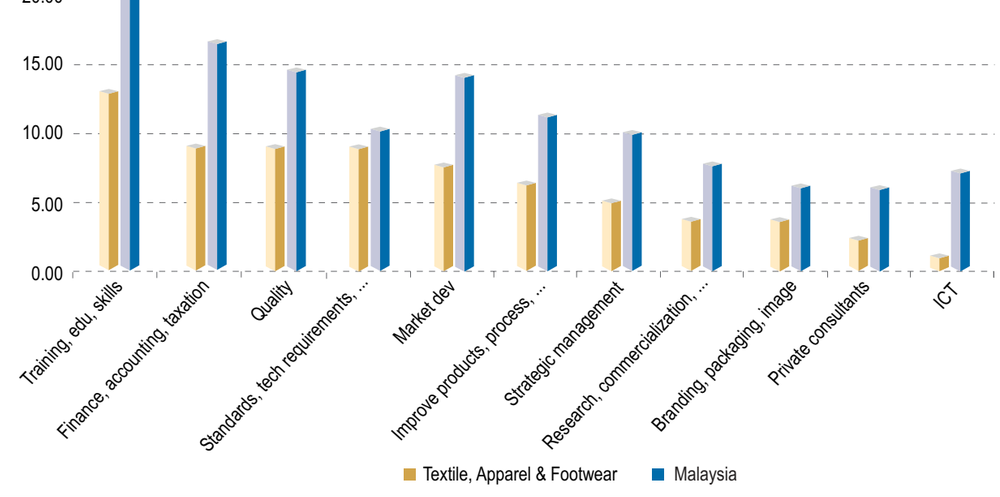


Figure 10.12: Role of Institutional Environment in Skill Building of the Textile, Wearing, Apparel and Footwear Industry



The institutional environment in Malaysia plays a significant role in supporting capabilities building. While there is a variety of services available, they remain underutilised, as depicted in **Figure 10.12.** There is some activity in building human capability from training, education and skills upgrading, but this is at a level which is only half the national aggregate. Similarly, there is limited activity in all the other skills building activities, with the least in ICT.

The textile, wearing, apparel and footwear industry does not appear to be very receptive to advice and assistance as observed by each component, scoring much lower than the Malaysian aggregate. Many of these SMEs are craft based entities with few resources and manpower. The SMEs are linked to TWAF value chain through large OEM contracts operating an extensive SME network.

10.5.3 Innovative Capability

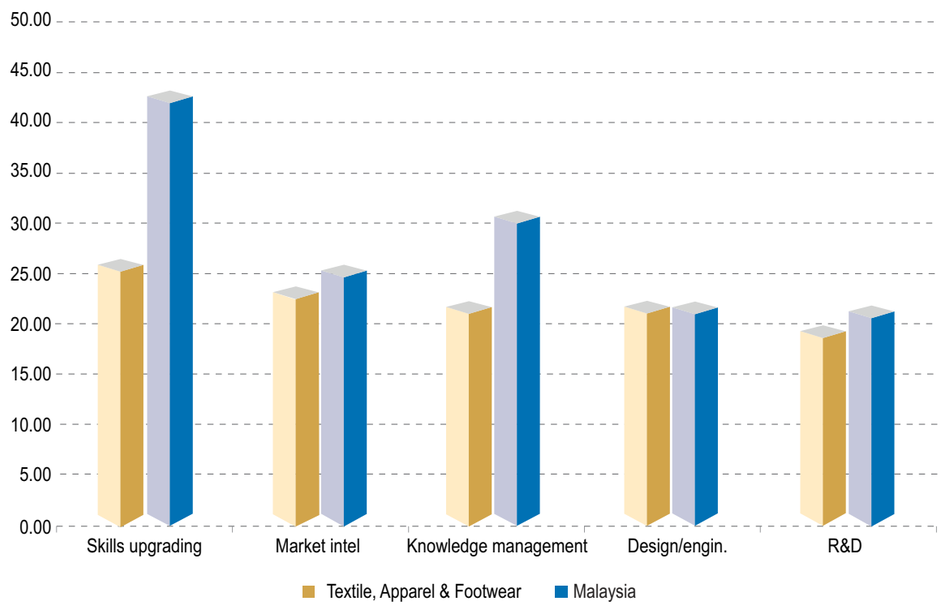
Having a high level of innovative capability endows firms with the ability to assimilate external knowledge with internal organisational processes and people in order to create new products and services. The textile, wearing, apparel and footwear industry performs moderately well in its innovative capability, at a level which is slightly above the national aggregate. However, performing slightly better than average is insufficient to produce innovative outcomes – it is also necessary to make resources available to devote to developing market understanding.

Figure 10.13 shows that the textile, wearing, apparel and footwear industry needs to engage more in innovative capabilities activities. In particular, it needs to focus on upgrading skills, an activity which is well below the national aggregate. A possible reason for the lower skills level is because the industry only requires simple automation therefore there is no need for highly skilled technicians to operate these machines. There is also a lower-than-average level of market intelligence, knowledge management and R&D. Being predominantly OEM manufacturers may mean that the firms in the industry do not need to actively engage in these activities since its focus is only on meeting their customers' specifications in the most efficient manner. On the positive side, the design and engineering is just a notch higher than the national average and this is suggestive of the industry making a move towards more advanced automation in its manufacturing processes.

10.6 Outcomes of Dynamic Capabilities in the Textile, Wearing, Apparel and Footwear

The textile, wearing, apparel and footwear industry has a strong domestic presence, with 74% of its revenue originating from the domestic market. Out of this amount, 48% comes from within the state sales and 26% from national sales. Its export sales generates 26% of its total revenue, with almost equal share between regional (12%) [ASEAN + China, Korea and Japan] and international (14%). While there is some presence both regionally and internationally, the main contributor remains firmly in the domestic market.

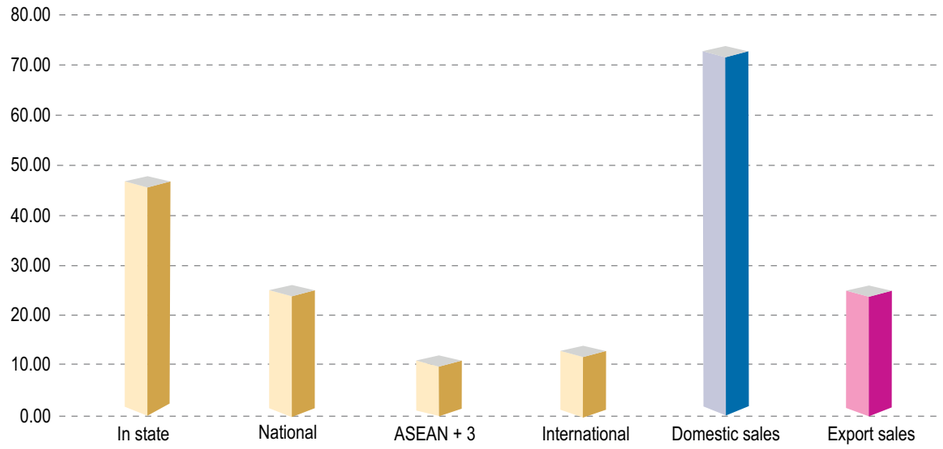
Figure 10.13: Knowledge Intensive Activities in the Textile, Wearing, Apparel and Footwear Industry



The textile, wearing, apparel and footwear industry firms' strategic profile in **Figure 10.15** reveals that the industry is dominated by Defender firms (54%), at a much higher level than the Malaysian aggregate. Defenders prefer to focus on a few selective products and aim for quality and operational efficiency. The next group, Analysers make up 18.4% of firms in the industry, followed by Reactors (14.5%) and Prospectors (13.1%). For Defenders, profit maximisation and repeat customers are their businesses' modus operandi. Although Defenders can be successful in a declining industry or in a stable environment, the TAWF industry now faces aggressive competition from countries in the region, including China, Vietnam and Cambodia, all vying for OEM manufacturing contracts for the major brands in the US and Europe.

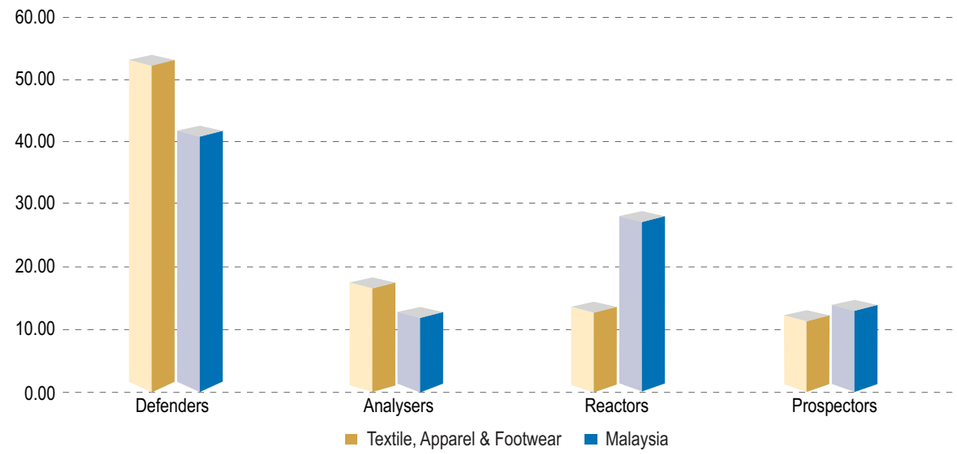
On the up side, a significant one-third of the firms in the textile, wearing, apparel and footwear industry are Prospectors and Analysers – these are the firms which will be willing to take the risk to invest in moving up the value chain (although Analysers will only do so with much analysis) to venture into ODM and OBM.

Figure 10.14: Market Presence of the Textile, Wearing, Apparel and Footwear Industry



Note: The results are based on survey data.

Figure 10.15: Strategic Profile of Firms in the Textile, Wearing, Apparel and Footwear Industry



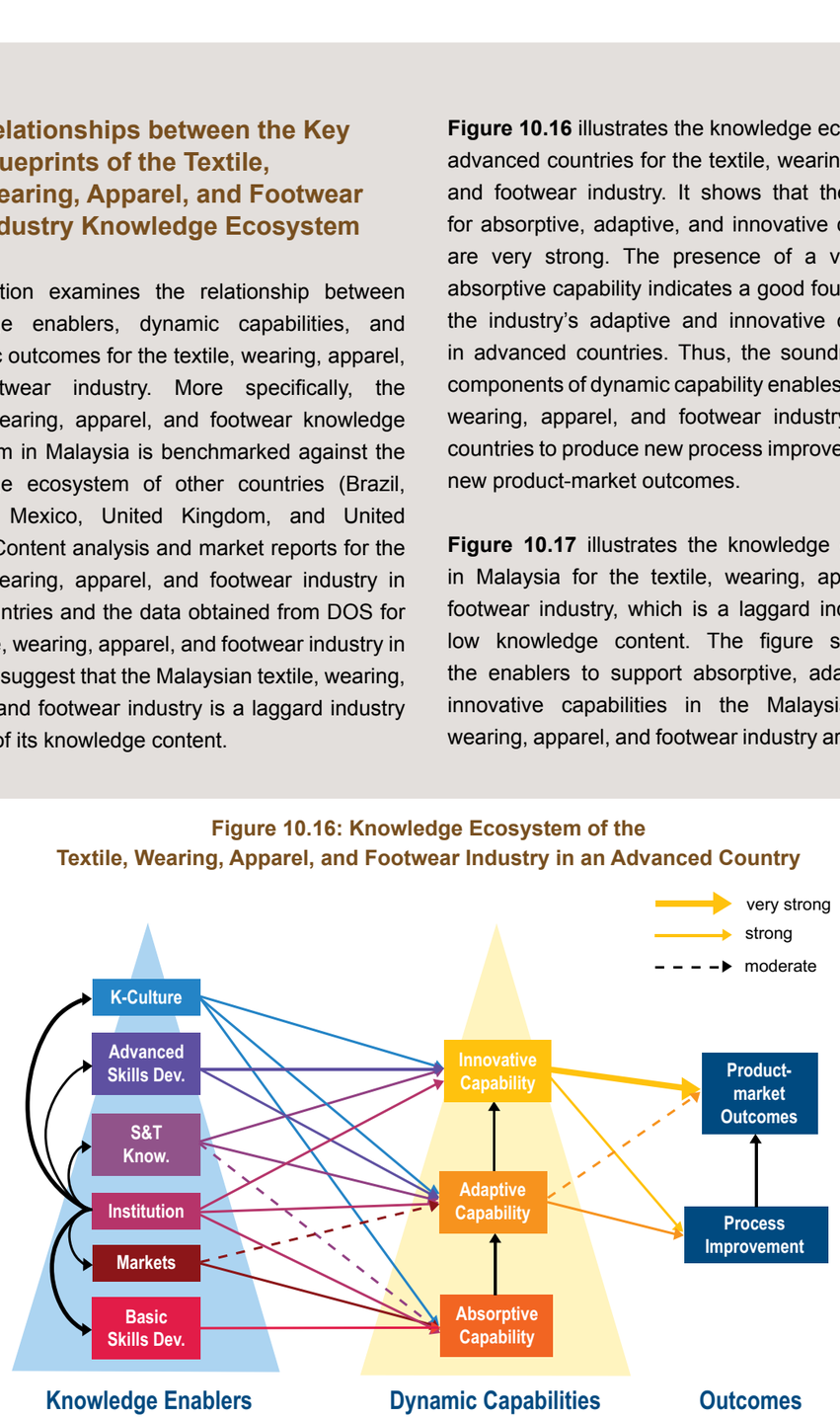
10.7 Relationships between the Key Blueprints of the Textile, Wearing, Apparel, and Footwear Industry Knowledge Ecosystem

This section examines the relationship between knowledge enablers, dynamic capabilities, and economic outcomes for the textile, wearing, apparel, and footwear industry. More specifically, the textile, wearing, apparel, and footwear knowledge ecosystem in Malaysia is benchmarked against the knowledge ecosystem of other countries (Brazil, Canada, Mexico, United Kingdom, and United States). Content analysis and market reports for the textile, wearing, apparel, and footwear industry in other countries and the data obtained from DOS for the textile, wearing, apparel, and footwear industry in Malaysia suggest that the Malaysian textile, wearing, apparel, and footwear industry is a laggard industry in terms of its knowledge content.

Figure 10.16 illustrates the knowledge ecosystem in advanced countries for the textile, wearing, apparel, and footwear industry. It shows that the enablers for absorptive, adaptive, and innovative capabilities are very strong. The presence of a very strong absorptive capability indicates a good foundation for the industry's adaptive and innovative capabilities in advanced countries. Thus, the soundness of all components of dynamic capability enables the textile, wearing, apparel, and footwear industry in these countries to produce new process improvements and new product-market outcomes.

Figure 10.17 illustrates the knowledge ecosystem in Malaysia for the textile, wearing, apparel, and footwear industry, which is a laggard industry with low knowledge content. The figure shows that the enablers to support absorptive, adaptive, and innovative capabilities in the Malaysian textile, wearing, apparel, and footwear industry are relatively weak. Components of dynamic capabilities, particularly absorptive and adaptive capabilities, are mainly directed toward process improvement. To further understand the relationships between knowledge enablers and dynamic capabilities for the industry in advanced textile sector countries and in Malaysia. A summarise d explanation behind the findings are provided in **Table 10.1.**

Figure 10.16: Knowledge Ecosystem of the Textile, Wearing, Apparel, and Footwear Industry in an Advanced Country



Note: Very strong impacts are represented by the bolded line, strong impacts are represented by normal lines and moderate impacts are represented by dotted lines.

Figure 10.17: Knowledge Ecosystem of Textile, Wearing, Apparel, and Footwear Industry in Malaysia

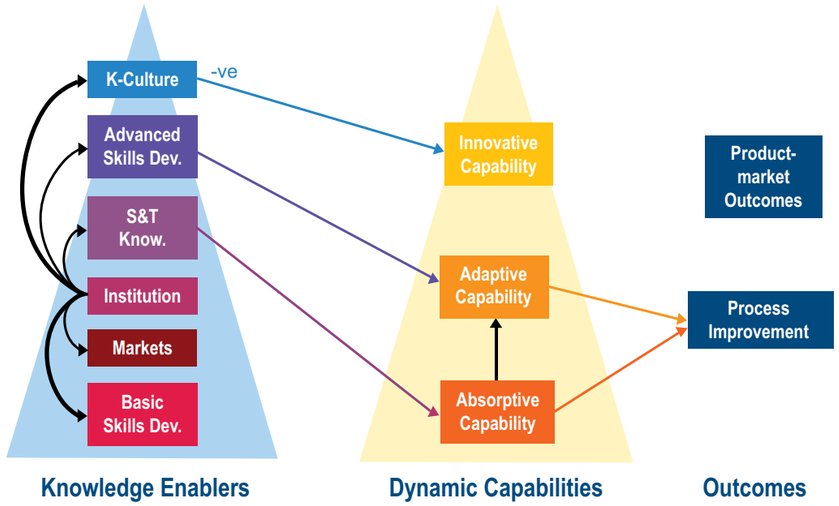


Table 10.1: Knowledge Enablers and Dynamic Capabilities for the Textile, Wearing, Apparel, and Footwear Industry

Advanced Countries	Malaysia
Basic Skills have a **positive and strong impact** on absorptive capability. In most advanced textile sector countries, the textile, wearing, apparel, and footwear industry is a vital source of revenue. Significant resources are provided to textile, wearing, apparel, and footwear manufacturers to continuously improve their basic knowledge (e.g. education from community colleges, technical colleges, polytechnics, and universities). The advanced textile, wearing, apparel, and footwear industry is reasonably technology and knowledge intensive – for example, advanced technologies and sensory technologies are used and embedded in clothing. Continuous development and regular trainings are provided to help textile, wearing, apparel, and footwear manufacturers to keep themselves updated with the most recent advances and knowledge.	Basic Skills have **no significant impact** on any of the components of dynamic capability. The Malaysian textile, wearing, apparel, and footwear industry is a labour intensive industry that is highly dependent on foreign labour from neighbouring countries with minimal amount of resources invested to train foreign recruits. As such, the study finds that the competitiveness of the Malaysian textile, wearing, apparel, and footwear industry turns on cheap labour cost.

Table 10.1: Knowledge Enablers and Dynamic Capabilities for the Textile, Wearing, Apparel, and Footwear Industry (cont'd)

Advanced Countries	Malaysia
Market intelligence has a **positive and strong impact** on absorptive capability and a positive and moderate impact on adaptive capability. The interactions of myriad stakeholders (e.g. suppliers, customers, competitors, external consultants, R&D centres, and logistic providers) are key in the absorption and adaptation of new knowledge, technology, systems, and processes in advanced textile, wearing, apparel, and footwear industries. This, in turn, creates a positive impact on their productivity and efficiency. There is also significant investment in R&D by both public and private institutions and a widespread use of ICT. Additionally, across the supply chain in the industry, there is a strong emphasis in process technologies and specific adaptations of emerging technologies, and thus most firms are able to make process improvements and introduce high value products into the marketplace.	Market intelligence **has no significant impact** on any of the components of dynamic capability. The interactions among key stakeholders in the Malaysian textile, wearing, apparel, and footwear industry are patchy and fragmented. In particular, partnerships with key stakeholders are often dominated by monopolistic behaviour. This creates a 'lock-in' effect that prevents textile, wearing, apparel, and footwear manufacturers from getting the best technology, knowledge, or innovations. The use of ICT and new technology is also relatively low as the Malaysian textile, wearing, apparel, and footwear industry is plagued by intermediaries and 'rent-seeking' behaviour.
Institutions are **strong enablers** of the knowledge ecosystem and have **direct strong and positive impact** on all three components of dynamic capability. The government at all levels (i.e. federal, state, local) takes considerable effort to ensure that the textile, wearing, apparel, and footwear industry is well connected to other key institutions that directly and indirectly enhance productivity, efficiency, and market reach of textile, wearing, apparel, and footwear manufacturers in advanced countries. Government research institutions (GRI), universities, regulators, and trade associations receive many fiscal and non-fiscal incentives. They play an active role in shaping the textile, wearing, apparel, and footwear ecosystem. Institutions in advanced countries have a direct influence on building dynamic capabilities in the textile, wearing, apparel, and footwear knowledge ecosystem.	Institutions have a **strong impact on the enablers,** but **do not have any direct impact** on all three components of dynamic capability. Institutions (e.g. regulators, trade association, universities, and government agencies) in Malaysia are vital to the development of the local textile, wearing, apparel, and footwear industry. Yet, the study shows that institutions do not produce any significant impact on the components of dynamic capability of firms in the Malaysian textile, wearing, apparel, and footwear industry. Among the reasons behind such an unfavourable phenomenon is the absence of centres of excellence to conduct research and produce new innovations, poor accessibility to new knowledge and technology, and poor quantity and quantity of local talent pool.

Table 10.1: Knowledge Enablers and Dynamic Capabilities for the Textile, Wearing, Apparel, and Footwear Industry (cont'd)

Advanced Countries	Malaysia
S&T knowledge has a **positive and moderate impact** on absorptive capability, but a positive and strong impact on adaptive and innovative capabilities. Strong basic and applied R&D activities focussed on the specific requirements of the textile, wearing, apparel, and footwear-related areas are present in advanced countries. There is a strong focus on key strategic areas to enhance the productivity of textile, wearing, apparel, and footwear manufacturers, and significant resources are invested to help them become globally competitive. Among the investments made include continuous upgrading of technological infrastructure and research centres. There is also strong support for start-ups with high-value offerings to penetrate the market.	S&T knowledge has a **positive and strong impact** on absorptive capability. There is weak basic and applied R&D activity areas relevant to textile, wearing, apparel, and footwear. This is compounded by a lack of talent pool for high quality research and innovative solutions geared specifically for textile, wearing, apparel, and footwear manufacturers. Weak industry-university partnerships have led to a high dependence on foreign technology. S&T knowledge that takes place within Malaysia is mainly to improve the absorptive capacity of Malaysian textile, wearing, apparel, and footwear manufacturers.
Advanced Skills have **a positive and strong impact** on both innovative and adaptive capabilities. The strength of research and business process modules (e.g. production, marketing, accounting) to support firms in the textile, wearing, apparel, and footwear industry in advanced countries is attributed to significant investment in the education and training to develop advanced skills. A strong partnership between textile, wearing, apparel, and footwear manufacturers and their stakeholders also create seamless facilitation of knowledge to bridge the 'knowledge-commercialisation chasm.' This strengthens their adaptive and innovative capabilities.	Advanced Skills have **a positive and significant impact on adaptive capability.** Significant resources are invested to improve skills and R&D capabilities in Malaysia. However, the graduates and talent pool produced remain as agents who adapt existing and foreign technology or knowledge. Most textile, wearing, apparel, and footwear manufacturers do not undertake R&D or innovative endeavours in emerging new areas of development.
Knowledge culture has a **positive and strong impact** on all three components of dynamic capability. High industry-relevant knowledge competency (e.g. through data and market reports from governments and trade associations) and high ICT literacy among textile, wearing, apparel, and footwear manufacturers is present in advanced sector	Knowledge culture has **a negative impact** on innovative capability. Low industry-relevant knowledge competency and ICT literacy are present among Malaysian textile, wearing, apparel, and footwear manufacturers. A strong dependency for knowledge and technology is also prominent feature of the industry. Malaysian textile, wearing, apparel, and

Table 10.1: Knowledge Enablers and Dynamic Capabilities for the Textile, Wearing, Apparel, and Footwear Industry (cont'd)

Advanced Countries	Malaysia
countries. Most textile, wearing, apparel, and footwear manufacturers are well informed about market developments and innovations that are taking place inside and outside their countries.	footwear manufacturers are reluctant to undertake new innovations and creative ways to enhance productivity and seize market opportunities. Instead, these manufacturers rely on foreign knowledge and technology in their operations and manufacturing processes.
The continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** The quality and quantity of textile, wearing, apparel, and footwear products in advanced countries is raised through scientific and technological breakthroughs at leading centres of excellence. Manufacturers in the textile, wearing, apparel, and footwear industry adhere to global environmental standards and best practices, which in turn contributes to their competitiveness in the local and global marketplace.	The continuum from absorptive capability to adaptive capability to innovative capability **is present.** Weaknesses in the talent pool is present in the Malaysian textile, wearing, apparel, and footwear industry despite significant investments to improve the quality and quantity of industry-relevant graduates and workers. There is an insufficiency of talented individuals in the industry who are passionate and devoted to produce new and innovative textile, wearing, apparel, and footwear products. Thus, there is a lack of new textile, wearing, apparel, and footwear product-market outcomes.

Table 10.2 provides a summary of the impact of dynamic capabilities on economic outcomes for advanced countries' and Malaysia's textile, wearing, apparel, and footwear industry. When advanced countries are examined, adaptive capability was found to produce a positive and strong impact on process improvements and a positive and moderate impact on product market outcomes, whereas innovative capability was found to have a positive and strong impact on process improvement and a very strong to product-market outcomes. These findings suggest that the textile, wearing, apparel, and footwear industry in advanced countries strongly produces process improvement and new product-market outcomes.

In contrast, the absorptive and adaptive capabilities of Malaysian textile, wearing, apparel, and footwear manufacturers were found to have a strong and positive impact on process improvement, but innovative capability was not found to have any significant impact on process improvement or new product-market outcomes. This may be attributed to the high dependence on cheap foreign labour and the strong focus on becoming cost competitive through the adoption and adaptation of foreign technology.

Table 10.2: Dynamic Capabilities and Economic Outcomes for the Textile, Wearing, Apparel, and Footwear Industry

Advanced Countries	Malaysia
Adaptive capability has a p**ositive and strong impact** on process improvement and a positive and moderate impact on product-market outcomes. Most SME manufacturers in the textile, wearing, apparel, and footwear industry in advanced countries are very strong in adapting new technology and innovations to improve existing processes and product-market outcomes. In many instances, SMEs supply their products to MNCs in the industry. MNCs in the industry through their control of the supply and retail of textile, wearing, apparel, and footwear products often gain economies of scale and scope at the international level.	Absorptive and adaptive capabilities have **positive and strong impact** on process improvement. Most Malaysian textile, wearing, apparel, and footwear manufacturers are labour intensive and not technological advanced. They rely on cheap foreign labour and use foreign technology to improve their processes and value chain. Few breakthrough textile, wearing, apparel, and footwear products are produced and promoted in the marketplace.
Innovative capability has a **positive and strong impact** on process improvement and a **positive and very strong impact** on product-market outcomes. There is significant investment in R&D and skilled workforce. This contributes to greater process efficiency and productivity. Many large MNCs in this industry have global reach and richness in their products. They primarily compete on developing very strong brand identity.	Innovative capability **has no significant impact** on process improvement and product-market outcomes. Adoption of new technology and innovations from more advanced countries to improve cost-efficiency, service quality, and meet domestic market demand prevails among textile, wearing, apparel, and footwear manufacturers in Malaysia. Very little R&D is undertaken by manufacturers in Malaysia. Innovations that do take place often do not have any significant impact on product-market development.
Process improvement has a positive and **moderate impact** on product-market outcomes. Manufacturers in the textile, wearing, apparel, and footwear industry form strong partnerships with their stakeholders in advanced countries. In turn, this enables them to translate process improvements into new textile, wearing, apparel, and footwear products that are globally competitive.	Process improvement **does not have any impact** on product-market outcomes. Process improvements undertaken by manufacturers in the Malaysian textile, wearing, apparel, and footwear industry are reliant on foreign technology and intellectual property. There is limited creation of new textile, wearing, apparel, and footwear products.

10.8 Summary: Key Trends, Challenges, Way Forward and Best Practices

10.8.1 Industry Trends

The moderate pool of dynamic capabilities for the textile, wearing, apparel and footwear industry is a result of the slow progress in building its knowledge resources foundations. Human capability is of greatest concern in the industry, having regressed even lower than its 2003 level. In addition to its inability to attract talent, firms in the industry are not providing sufficient training and education to enhance their current employees' skills. Limited progress in automating their manufacturing processes may be a reason for not focusing on skilling up talent. This will need to change if firms in the industry are to automate through the government's automation capital allowance incentive.

Although the industry does moderately well in one element of its dynamic capabilities, that is, leveraging on their existing market knowledge and technological capability to improve new products (innovative capability), it is below average performance in investing in innovation and marketing capability (adaptive), and in scanning the market environment for new customer insights and opportunities (absorptive). This means the industry is largely unable to produce strong innovation outcomes. Profile of each of the dynamic capability components show that the industry falls behind other Malaysian industries in almost every capability building activity. Overall, the industry may struggle to remain competitive because it is not sufficiently endowed with the dynamic capabilities to adapt to technological, environmental and competitive changes. This is of concern, as the Malaysian TWAF industry faces increasing competition from emerging low-cost production countries such as China, Indonesia, Vietnam, Pakistan, Sri Lanka and Bangladesh.

10.8.2 Challenges

The textile, apparel and footwear industry is undergoing a challenging period. This can be attributed to increasing competition from regional players who have better economies of scale and scope. The challenges experienced by the industry are also due to several inherent weaknesses in the local ecosystem that prevent the industry from carving out niche areas where it has comparative and competitive advantage. Below are some of the key challenges experienced by the industry:

Institutions:

- Poor cooperation between industry stakeholders due to lack of formalised collaborative frameworks.
- No clear sector incumbent to champion creation of centres-of-excellence to spearhead materials research or process innovations.
- New knowledge and technology are not efficiently disseminated to players, most of which are fragmented small enterprises.
- Underdeveloped talent pool among local institutions aggravated by poor knowledge management and informal training.

Basic Skills Development:

- Market remains labour-intensive, with relatively little levels of automation compared to leading global producers.
- Over-reliance on low-tier human capital has led to labour shortages, as inadequate job conditions fail to attract workers.
- Majority of workers comprise foreign labour with minimal skillsets; minimal investments are made to scale-up competencies.
- Low employer expectations, high staff turnover, minimal English language proficiency and uncertain market outlook discourage firms from investing into skill development programmes.
- Cost-oriented competitive models remain the dominant means of doing business; and firms are reactive to change rather than proactive innovators.

S&T Knowledge:

- Limited R&D initiatives truncate the industry value chain, and ultimately give rise to unsophisticated propositions.
- Existing business models are non-conducive to attracting the right talent to facilitate research and best practice origination.
- Inclination to depend on foreign technology due to weak collaboration with universities, and the absence of related research conducted by the latter.
- Locally developed knowledge to have effect requires stronger development of absorptive capacity of local industry manufacturers in order to fully realise benefits.

Advanced Skills Development:

- Skills of graduates do not meet the needs of creative workers in the industry. Most graduates are proficient users of foreign S&T but are not creators of new innovations.
- Global market developments and emergent opportunities are not adequately addressed by R&D efforts.
- Transition toward industry automation is hampered by insufficiency of localised technical support.

Market Intelligence:

- Information sharing and knowledge synergies between industry stakeholders are infrequent, due to inward competitive focus.
- Partnerships with major stakeholders create undesirable 'lock-in' dependencies among smaller players.
- Low use of ICT and new technologies.
- Prevalent 'rent-seeking' discourages businesses and workers from investing in deepening capabilities.

Knowledge Culture:

- Low ICT literacy creates a logistically prohibitive environment for knowledge dissemination.
- Strong dependency on foreign knowledge and technology to sustain (and rarely, advance) industry practices.
- Strong risk aversion among decision-makers drives firms away from innovative pursuits as well as weakness in quickly acting on market opportunities.
- Reliance on transient foreign labour precludes bottom-up knowledge/capability development.

10.8.3 Way Forward

The Malaysian textile, apparel and footwear industry faces stiff competition from emerging countries, such as China and India. To ensure the firms in the industry enhance their knowledge intensity and competitive position, the following are proposed to strengthen the textile, apparel and footwear knowledge ecosystem.

Recommendation 10.1: Encourage Greater Domestic Investments in Strategic Areas

- Encourage local manufacturers operating overseas to transfer operations back to Malaysia by developing and enhancing domestic supply chain ecosystems as well as logistic capabilities in favour of textile production.
- Mandate local companies to recalibrate operations toward upstream production, where they retain brand advantage and do not need to compete as intensively with an already saturated global downstream market.
- Provide tax incentives, reinvestment allowances and other facilitating measures to local companies to encourage operations and activities locally and migrate to Industrie4.0.

Recommendation 10.2: Focus on Import Substitution

- Align local production toward the creation of goods that directly compete against in-demand foreign textile commodities.

- Engage local firms to co-develop G2M strategies aimed at maximising existing market presence, consumer knowledge and channel reach, in order for them to viably compete against foreign counterparts.

- Government to stimulate demand ecosystem by reinforcing local brand purchase behaviour, such as the "Buy Malaysia" campaign.

- Incentives should be provided to local manufacturers to expand their value propositions (not just operations) for domestic consumers, and to extend their reach in the region.

Recommendation 10.3: Strategic Management of Human Capital

- Government to make a detailed assessment of industry needs for human capital and provide preapproved blocks of foreign workers over a given period of time to address labour shortages, with the purpose of weaning the industry from its dependency on cheap foreign worker towards technology-intensive operations.

- Appoint and empower industry associations to enforce specific quotas to refine the recruitment of foreign workers, and thereby creating the right formal labour channels regionally to attract skilled workers (only when required).

- Ensure cost-effective continuous training programs and certifications are available via colleges and polytechnics to better align the curriculum to topical, industry-specific needs.

- Foster strong strategic partnership between the established institutions, SMEs and universities via programs such as the Small Business Innovation Research (SBIR) programs where public universities and technical colleges serve as anchors to scale-up local talent as well as industry IP.

Recommendation 10.4: Promote Industry-Relevant Certification and Global Best Practices

- Ensure the industry meets global best practices and standards, which is key to market penetration of global markets.

- Create/appoint a dedicated commission tasked with training textile workers toward formal certification and adherence to global best practices, thus ensuring skilled individuals are accorded the appropriate industry recognition and career prospects, allowing them to move the industry up the global innovation value chain.

10.8.4 Best Practices

The global textile, apparel and footwear are dominated by key players such as China, India, Bangladesh and other developing countries where cost of labour and production are relatively cheaper than Malaysia. In spite of the global industry dynamics, several developed countries with relatively smaller labour force have maintained their market dominance through the use of more sophisticated technology and 'know-how'. Many of these countries have moved their industries up the knowledge and innovation value chain. Firms in these countries are continuously introducing new products, services and designs that cater for the diverse global markets. Some of the best practices from these knowledge-intensive textile, apparel and footwear ecosystems are discussed below.

Best Practice 10.1: Encourage Greater Domestic Investments in Strategic Areas

Japan Textile Federation (JTF)

- JTF, a key industry association plays a key role in promoting the development of new materials, products, technologies and applications in the industry. JTF works closely with key stakeholders to ensure the following:
  - Japanese firms continuously develop new materials and products using advanced technology and new scientific breakthroughs in advanced materials and fibres.
  - The industry continuously strengthens interactions between production processes, from raw materials to high-order processing, including designing and sewing. This enables the firms in the industry to constantly create high-value-added products and new applications for a wide spectrum of industries such as cars, aerospace, information and telecommunication, civil engineering, agriculture, forestry and fishery materials and medical services.
  - JTF plays an orchestrating role in mobilising other institutions (industry, universities, government agencies and community organisations) to invest in relevant resources, networks and linkages which enable local firms to develop new technologies that raise the innovative capability and efficiency of the local textile, apparel and footwear industry.
- JTF also fosters cooperation between different industries and pursue creation of new markets by capitalising on top-class technologies.
  - Continuous market analysis is undertaken to ensure products meet changing local and global trends. For example, JTD proposed the industry provides solutions for a wider range of industries which show high growth promise in the future such as "environment and energy," "health care industry" and "leading-edge industry (next generation vehicles, aviation and space industry, battery materials, etc.)". Significant investments and resources are channelled for R&D activities in high-performance and high-functional fibres and high-end textile technologies. These R&D activities and innovations are jointly undertaken with key universities and research centres in the country.
  - To ensure the Japanese industries are at the forefront of development and design, JTF fosters close collaboration with global centre of excellence with objectives of fostering knowledge-transfer and opening new markets for Japanese technology and products. Among the activities supported are the Japan-France Textile Cooperation Working Group and the annual symposium on advanced textiles, jointly which Japan Chemical Fibres Association (JCFA).

Best Practice 10.2: Focus on Import Substitution

Japan Textile Federation (JTF)

- JTF plays key role in promoting the Japanese brands that leverage on technology with sensibility (promotion of J∞QUALITY Project).
  - The strength of the Japanese textile industry is its high-quality, high-sensitivity and high-functional materials that incorporate sophisticated technology and meet the needs of Japanese fashion industry.
  - Information transmission activities include participation in the Milano Unica Exhibition where JTF exhibit their products.
  - JTF support "J∞QUALITY Product Certification Project" managed by Japan Fashion Industry Council (JFIC) as a main organisation which integrates efforts of the relevant industries.
- Support for appeal of Japan's textile and fashion goods in collaboration with "Cool Japan Strategy."
  - Under the "Cool Japan Strategy" implemented by the government, JTF works with related organisations in order to allow textile products ranging from fashion goods to functional goods to be promoted locally and internationally.

- To accelerate the progress of “Cool Japan Strategy” projects, subsidy and information dissemination programs are made available to firms.

- Increase visibility of the textile and apparel fashion industries through Japan Fashion Week.

- Japan Apparel Fashion Industry Council (JAFIC) and Japan Fashion Week Organisation organise regular promotional activities, focusing on the integration of “creation,” “artisanship” and “commerce.”

- Strong support is also provided for joint collaboration between creators and material production centres to enhance Japanese fashion and brands.

Best Practice 10.3: Strategic Management of Human Capital

Japan Textile Federation (JTF)

- There is a strong focus on ensuring the talent development strategy keeps pace with the technological development in the industry. To achieve this the following are undertaken:

  - Ensure there is continuous improvement in the human resources so that the workforce is able to absorb, adapt and develop new technology, fibres and design that lead the global textile industry.

  - Invest in talent and nurture the next generation workforce that will lead new designs and manufacturing of new nature-friendly fibres; and have sound knowledge of marketing, promotion and branding.

  - Improve systems and process to pass on advanced techniques, printing methods, cultural embroidery and design techniques to the next generation workers in the industry.

  - Concerted efforts are taken to reduce foreign workers and overcome shortage of workers in the industry. The following are some of the measures undertaken:

    - Promote employment of senior citizens and women.

    - Automate most of the processes that are labour intensive.

    - Foreign staff are employees in skilled categories with specific provision of knowledge and technology transfer to local workers and firms.

    - Labour intensive operations are undertaken in other developing countries where cost structures are relatively lower than Japan.

Best Practice 10.4: Promote Industry-Relevant Certification and Global Best Practices

The Japan Apparel-Fashion Industry Council

- Meeting Global Best Practices and Standards.

  - To expand to new markets overseas Japan has harmonised some of its standards to global best practices. The following are some initiatives that are undertaken:
    - Adherence to Guidelines on Harmful Substances; ISO standards for sizes of garments and apparel; Safety of Children’s Apparels; creation of handbook on harmful substances.

    - For Certification and Standards for Organic Cotton Products – Japan’s standard has been harmonised with the Global Organic Textile Standard (GOTS), which opens new markets in developed countries, where requirement standards are high.

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CHAPTER 9

KNOWLEDGE CONTENT OF THE TRANSPORT EQUIPMENT INDUSTRY

CHAPTER 9
Knowledge Content of the Transport Equipment Industry

9.0 Introduction

The transport equipment industry is classified into three sub-industries[3]: land transport (e.g., bicycle, motorcycle, automobile, heavy vehicles and special purpose vehicle inclusive of defence use.); marine or maritime (e.g., boats, barges, ferries, ships and special purpose vessels); and aviation or aerospace (e.g., air and spacecraft for commercial, industrial and military use). According to the Malaysia Standard Industrial Classification [MSIC] (2008), manufacturers of other transport equipment have been divided into five areas: building of ships and boats; manufacturer of railway locomotives and rolling stock; manufacturer of air and spacecraft and related machinery; manufacturer of military fighting vehicles; manufacturer of transport equipment 'not elsewhere classified' (or 'n.e.c.'). The focus of this section is the railway, maritime and aerospace sub-industries.

In 1993, the Malaysian Industry-Government Group for High Technology (MIGHT) was established as the lead agency to develop the high technology industries in Malaysia. Transportation is one of the eight strategic areas, focused on by MIGHT as an enabler of Malaysia's ascent to become a global industrial power house.

[3]The classification was from Ministry of International Trade and Industry [MITI] (2015).

Railway

Rail transport in Malaysia consists of heavy rail, light rail, monorail and funicular rail. Since its first operation in 1885, the Malaysian rail industry remains relatively small in terms of rail track network coverage and number of operating companies. There are about 160 companies engaging in rail-related activities (Malaysian Foresight Institute, 2016). The main rail operators in Malaysia offering intercity, suburban, high-speed, light rail, subway and cargo services include Keretapi Tanah Melayu (KTM), Prasarana, MRT Corporation, Express Rail Link, RapidKL, Sabah State Railways and Melaka Tram. Malaysia relies heavily on imported railway vehicle equipment and rolling stocks to modernise the rail transport in Malaysia.

The Malaysian Government's spending on transportation rose from RM14 billion in 2009 to RM18 billion in 2015 (Ministry of Transport, 2016). A number of initiatives such as the National Rail Industry Roadmap and the National Land Public Transport Master Plan (2012-2030) have been introduced and undertaken to improve the rail facilities to be on par with other developed countries. Among the Government agencies involved in rail transport are the Ministry of Transport, Land Public Transport Commission (SPAD), Ministry of International Trade and Industry (MITI), Railway Assets Corporation (RAC), Malaysia External Trade Development Corporation (MATRADE) and Standards and Industrial Research Institute of Malaysia (SIRIM).

Marine or Maritime

Shipbuilding and ship repair of the marine transport industry are the key industries identified in the Third Industrial Master Plan (IMP3), 2006-2020. The maritime industry has also been earmarked to provide offshore support vessels for the National Key Economic Area (NKEA) - oil, gas and energy. Shipbuilding is a manufacturing sub-industry, whereas ship repair is classified as a service-oriented sub-industry. These industries have a great impact in developing technological capabilities, industrial capacity and employment in Malaysia.

According to the Malaysia External Trade Development Corporation [MATRADE] (2016), the export of ships, boats & floating structures was valued at RM676.7 million in 2015. The top five exports of the above include vessels for goods and persons (RM244.3 million, 36.1% share), tugs and pusher craft (RM241.6 million, 35.7% share), motorboats other than outboard motorboats (RM60.9 million, 9% share), buoys, beacons, coffer-dams, pontoons and other floating structures (RM47.8 million, 7.1% share) and cruise ships, excursion boats etc principally designed for transport persons (RM46.1 million, 6.8% share). The Malaysian shipbuilding and ship repair industry remains relatively small, with 50% share of the domestic market and 1% share of the global merchant fleet. In 2011, the Malaysia Shipbuilding and Ship Repair Industry (SBSR) Strategic Plan 2020 was launched to boost the industrial competitiveness of the local maritime industry. The goal of the Malaysia SBSR Strategic Plan 2020 is to service 80% of the Malaysian market and 2% of the international new build market. The target for the ship repair market is to extend coverage to 3% of the vessels plying the Straits of Malacca, and to account for 80% of the South China Sea offshore ship repair. These will generate revenue amounting to RM19.09 billion and create 55,500 jobs (Malaysia Shipbuilding and Ship Repair Industry Strategic Plan 2020, 2011).

According to Malaysian-German Chamber of Commerce and Industry (2013), there are over 120 registered shipbuilding and ship repair companies in Malaysia, with 48 companies located in the Peninsular and 72 located in East Malaysia. The shipyards are clustered around Selangor (Port Klang), Johor (Pasir Gudang), Perak (Lumut), Penang (Jerejak), Terengganu (Kemaman), Sabah (Labuan) and Sarawak (Sibu). Among the business activities included are construction of ocean-going vessels, tug boats, patrol vessels, supply vessels, fishing vessels, landing craft, passenger ferries and boats, small tankers and leisure craft, construction of offshore structure for the oil and gas industries, ship repair, maintenance, upgrading, overhauling and refurbishing of vessels, conversion of ships, heavy engineering and fabrication of offshore structures, steel structures and cranes (MATRADE, 2015). Recently, Malaysia Marine and Heavy Engineering managed to register full capacity, that is, 15 vessels

and rigs in its docks for ship repair (The Motorship, 2015); this is the second time in its history that it was able to do so.

The conception of the Malaysian shipyard industry occurred in Sarawak. Today, Sarawak has grown to become the hub of Malaysia's shipbuilding or ship repair industry due to its geographical location and proximity to the oil and gas market. Sarawak houses about 40 shipyards include small and big players such as Far East Shipyard Co Sdn Bhd, Tuong Aik Shipyard Sdn Bhd, GimHwak Group, Vitawani Eastern Marine and SL Shipbuilding. The shipyards in Sarawak are mainly family businesses. The companies in the Peninsular Malaysia's cluster are less competitive in the global market as they are highly dependent on government contracts in providing steel and aluminium vessels for Government and oil and gas companies. Examples include Boustead Naval Shipyard Sdn Bhd, Grade One Marine Shipyard Sdn. Bhd, Malaysia Marine and Heavy Engineering Holdings Berhad (MHB) and etc.

Among the regulators, key agencies and associations involved in the development of the marine sub-industry are the Ministry of Transport, Marine Department Malaysia, Malaysian Maritime Enforcement Agency, Royal Malaysian Navy, Royal Malaysian Customs Department, Sarawak River Board (LSS), Ministry of Agriculture and Agro-based Industry Malaysia (LKIM), Association of Marine Industry of Malaysia (AMIM), Malaysia Ship owners' Association, Maritime Institute of Malaysia (MIMA) and Malaysia OSV Owner's Association, Sarawak & Sabah Ship owners Association (SSSA).

Aerospace

The aerospace industry in Malaysia has grown rapidly since the 1990s, driven primarily by the introduction and implementation of the National Aerospace Blueprint in 1997. This blueprint outlines strategic measures on aerospace manufacturing, commercial aviation, general aviation, system and space, to develop Malaysia into a global aerospace player by 2015.

The Malaysian Aerospace Council (MAC) was set-up in 2001 to assist in the development of the aerospace industry. The four main focus areas of the MAC include maintenance, repair and overhaul (MRO); parts and components manufacturing; systems integration and avionics; and aerospace training and education. In the Economic Transformation Programme (ETP), two Entry Points Projects (EPP) (EPP1: Growing the MRO services; EPP5: Growing large pure play engineering services) have been planned to grow the aerospace industry. The aim of the EPPs is to develop globally competitive MRO services and aerospace engineering services to attract more foreign investment and high-value aerospace engineering services. EPP 1 is projected to generate RM13.4 billion gross national income (GNI) by 2020 by the MRO industry. More recently, the Malaysian Aerospace Industry Blueprint 2030 was introduced to chart a new direction for Malaysia to be a regional champion by year 2030. The blueprint is projected to contribute revenue of RM35 billion and create 32,000 jobs.

Today, there are over 150 local and foreign companies participating in Malaysia's aerospace industry. Major local companies include SME Aerospace Sdn. Bhd., Airod Sdn. Bhd., Upeca Aerotech Sdn. Bhd., Malaysia Aerospace Engineering Sdn. Bhd. (MAE), CTRM Aero Composites Sdn. Bhd., Strand Aerospace (M) Sdn. Bhd., Aeromek Mfg. Sdn. Bhd. Notable foreign aerospace companies operating in Malaysia originate from the US (e.g., GE Malaysia Sdn. Bhd., AAR Landing Gears Sdn. Bhd., Honeywell Aerospace Avionics (M) Sdn Bhd, Spirit Aerosystem Malaysia Sdn. Bhd.), Germany (e.g., Airfoils Services Sdn. Bhd.), Japan (IAC Manufacturing Sdn. Bhd.), France (e.g., Eurocopter Malaysia Sdn. Bhd., Messier-Bugatti-Dowty (M) Sdn. Bhd.), and Singapore (e.g., Aviatron (M) Sdn. Bhd). In 2014, the Malaysian aerospace industry reported a revenue of RM19 billion and RM4.2 billion in investments, and the creation of 19,500 jobs.

Government departments and agencies involved in the development of the aerospace industry include the Malaysian Aerospace Council (MAC), Department Civil Aviation (DCA), Ministry of Transport, the Royal Malaysian Air Force, Malaysian Investment Development Authority (MIDA), and Ministry of International Trade and Industry (MITI).

9.1 Key Developments and Initiatives

There have been several developments in the transport equipment industry and these include legislative reforms and regulations, finance, education and training, changes in the global markets, incentives introduced to develop the industry and research and development activities in the industry. The developments are summarised below.

Legislations

Under the Malaysian Law (Merchant Shipping Ordinance 1952), the national cabotage policy has restricted the domestic waterborne trade to Malaysian flagged vessels, and vessels "owned by" and "crewed by" Malaysian citizens. In recent years, some countries such as Indonesia have introduced a more restrictive cabotage policy to exclude the import of older ships to protect its national shipbuilding industry. Looking ahead, the Malaysian national cabotage policy should be revised to offer a healthy competition between the local and global companies to promote the domestic shipbuilding and ship repair industry.

Finance

In Malaysia, ship financing is challenging as most local and foreign banks do not regard shipping as the backbone of the Malaysian economy and that Malaysian firms do not have the expertise and technology to compete with firms from larger and more technology savvy countries such as Korea, China and Japan. There are very few financial institutions operating in Malaysia that provide financial assistance to existing and new companies engaged in shipping, shipyard, maritime related activities and oil and gas industry.

In Budget 2014, the Malaysia Government allocated RM3 billion in soft loans under the Maritime Development Fund through Bank Pembangunan Malaysia Berhad. Exim Bank has offered Overseas Project/Contract/Investment Financing (OPF/OCF/OIF) and Export of Services to facilitate the growth of new build projects. These financial assistances are critical for shipping companies to enhance local tonnage capabilities, undertake new build projects and other marine ancillary activities.

Education and Training

Human capital is the key to the growth of shipbuilding and ship repair industry. Although there are numerous training institutions (e.g., Institut Kemahiran Belia Negara (IKBN), Maritime Transport Training Institute, GIAT MARA, Institut Latihan Perindustrian (ILP)) in Malaysia, courses offered are mainly generic courses and do not meet the needs and requirements of the shipbuilding and ship repair industry. Table 9.1 shows the type of courses offered by the Maritime Transport Training Institute from 2010-2014.

Recently, some interesting training developments are driving the maritime industry. For example, China and South Korean dominate the international shipbuilding industry. The four largest (by vessel completions) Korean companies are namely Hyundai Heavy Industries, Daewoo Shipbuilding, Marine Engineering and Samsung Heavy Industries.

Table 9.1: Courses Offered by the Maritime Transport Training Institute, 2010-2014

Year	Generic Courses	Functional (General) Courses	Functional (Certificate of Competency, COC) Courses	Functional (Modular) Courses
2014	37	43	5	5
2013	44	50	5	6
2012	51	74	7	9
2011	29	32	2	5
2010	32	27	1	3

Source: Maritime Transport Training Institute (2015)

In 2014, in collaboration with MIGHT-METEOR Advanced Manufacturing Sdn Bhd (MMAM) and Daewoo Shipbuilding & Marine Engineering Co. Ltd (DSME), Boustead Heavy Industries Corporation Berhad offered a 14-month comprehensive training programme for staff to acquire the knowledge and skills of Korean best practices in shipyards and ship repair. Such a programme has increased the quality of training given to the local talent. More proactive actions are needed to establish collaboration between local and foreign institutions in offering quality education and training in the maritime industry.

For the railway industry, provision of skilled training is very limited to the Malaysian Railway Academy (MyRA) and Rapid Rail Academy. MyRA was established to provide rail-based training including operations, rolling stock maintenance, permanent way management and maintenance, and signalling systems. There are no specialised rail engineering courses offered in the colleges or institutions of higher education. In 2013, the Centre of Excellence for Rail was set-up under KTMB to train skilled workers in the rail industry. The course syllabuses offered by Centre of Excellence for Rail are reviewed by industry experts.

A number of human capital development programmes were launched to enhance the graduates' skills and knowledge in the aviation/aerospace industry. Specifically, the Aviation Maintenance Engineering (AME) is one of the training programmes featured in the Industrial Skills Enhancement Programme (INSEP) introduced by the Ministry of Finance in 2005. Later in 2010, a special bridging programme funded by the Ministry of Higher Education, known as "Leader in Domain Expertise for Aerospace (LEADER Aerospace)" was launched to train the engineering graduates to become certified aerospace design & structural engineers. This (LEADER Aerospace programme was a collaborative effort with industry players including Spirit AeroSystems Malaysia, CTRM Aero Composites Sdn Bhd and Strand Aerospace Malaysia Sdn Bhd.

The Malaysian Institute for Aviation Technology (MIAT) (currently parked under Universiti Kuala Lumpur (UniKL)) was founded in 2000 to develop the human capital in the aerospace industry. In 2009, the Advanced Composite Training Centre (ACTC) was set-up at UniKL-MIAT to provide skills training on aircraft parts sub-assembly and short courses on composites manufacturing. This training centre is supported by Spirit AeroSystems, one of the world's largest Tier 1 aero manufacturing companies.

Competition

At present, over 90% of the world's ship orders have been placed with Asian shipbuilders, mainly from China, South Korea and Japan. The Malaysian maritime industry still lacks the industrial capacity, knowledge and skills to compete in the global market. However, the maritime industry is one of the key areas in Malaysia's Economic Transformation Programme. Support for promoting shipbuilding and ship repair from the government is through a number of incentives such as exemption from import duty and sales tax on machinery, equipment and spare parts, foreign partnerships and joint ventures with the local companies.

Incentive

In January 2010, the Malaysian Government has introduced several tax incentives under the Income Tax Act (1967) for aerospace companies. To grow the aerospace industry, the incentive package (see Table 9.2 below) covers design, manufacturing and assembling, operator group, support and monitoring group.

Table 9.2: Incentives for the Aerospace Companies for Higher Valued Added Activities

Criteria	Incentives
Design, manufacturing and assembling group of activities comprising research, design and development and system integration.	Income tax exemption for a period of five to 15 years depending on the investment level, value-added, technology and other criteria.
Operator group comprising general aviation such as helicopter operation, charter, business jet operation to air recreational (e.g. Flying School, Flying Club and Hornbill Skyway Helicopter).	Investment Tax Allowance (ITA) of 100% on the qualifying capital expenditure within a period of 10 years subject to the investment in fixed assets exceeding RM150 million within five years.
Support group comprising maintenance, repair and overhaul activities (MRO) and training in aerospace, certification and maintenance.	Income tax exemption of 100% of statutory income for a period up to 10 years for companies which offer MRO services and services related to the production of aerospace finished products; Income tax exemption of 100% of statutory income for a period up to 15 years for companies involved in conversion, upgrading and refurbishment or remanufacture of aerospace finished products; Investment Tax Allowance (ITA) of 60% on the qualifying capital expenditure incurred within a period of five years for MRO companies operating in Malaysia which undertake expansion, modernisation or automation of current business or diversification of current business for related products in the same industry; or Double deduction on expenses incurred by employers providing pilot conversion and pilot instructor training
Pilot conversion and instructor pilot courses	Double deduction on expenses incurred by the employers in training their employees.
Regulatory group comprising companies undertaking aerospace related certification, standard development, testing and evaluation and licensing activities.	Pioneer Status (PS) with income tax exemption of 100% of statutory income for five years; or Investment Tax Allowance (ITA) of 60% on qualifying capital expenditure incurred within five years

Source: Malaysian Investment Development Authority (MIDA) (2015)

Research and Development

In the Malaysian railway industry, the level of research and development (R&D) on technology development is relatively low. New technology adoption often takes place through the process of reverse engineering. Most of the infrastructure development and upgrading is undertaken by the government.

The situation is different in the maritime industry, where the Maritime Institute Malaysia (MIMA) was established in 1993 to support R&D activities in this sector. To spearhead developments, five centres were established under MIMA – these being the Centre for Maritime Economics and Industries (MEI); Centre for Maritime Security and Diplomacy (MSD); Centre for Ocean Law and Policy (OLAP); Centre for the Straits of Malacca (SOM); and Centre for Coastal and Marine Environment (CMER). There are some joint marine training and technology development collaborations between local universities and government agencies. Recent example is the strategic collaboration between Universiti Teknologi Malaysia (UTM), Maritime Transport Administration and Management Training Institute (ILPPPL) and Marine Department Malaysia.

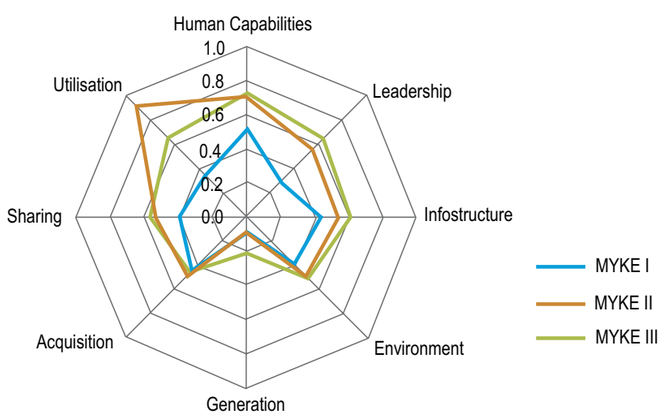
In the aerospace industry, the Aerospace Malaysia Innovation Centre (AMIC) was established in 2010 to spur R&D developments and technology transfer among global leading companies and local firms. The initiative is a joint venture between foreign companies (e.g., Airbus Group and Rolls Royce) and local companies (e.g., MIGHT, CTRM Aviation and Universiti Putra Malaysia) to enable 'knowledge spillover' to facilitate the local aerospace industries moving up the knowledge and innovation value chain.

9.2 Knowledge Content

In this study, the sample used to map the knowledge ecosystem for the Malaysian transportation equipment industry sector was based on the following samples for MYKE-I, MYKE-II and MYKE-III studies, respectively: 67, 57 and 40, as shown in Table 1.1. The number of SMEs and large players for the two sample periods were as follows: (SME, Large) are (50, 17), (25, 32) and (22, 18), respectively.

Changes in the knowledge resource foundations of the transport equipment industry over the period from 2003 to 2014 are shown in **Figure 9.1**. In MYKE III (2014), the transport equipment industry shows progress along all four dimensions of knowledge enablers, namely human capability, knowledge leadership, technology infostructure and knowledge environment. There is also a positive development in the elements of knowledge actions (i.e., knowledge sharing and knowledge generation) but a sharp fall in knowledge utilisation in 2014.

Figure 9.1: Overview of Knowledge Enablers and Knowledge Actions for MYKE I, MYKE II and MYKE III



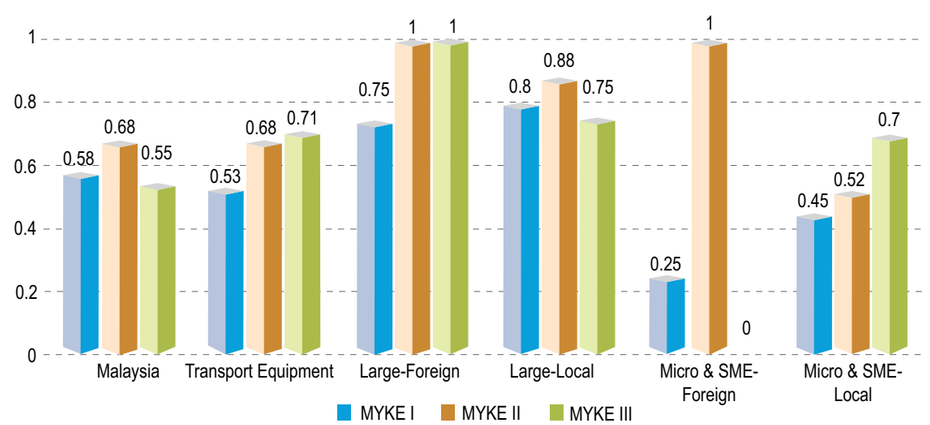
9.3 Knowledge Enablers

9.3.1 Human Capabilities

Human capability in the transport equipment industry improved consistently over the period from 2003 to 2014, increasing from 0.53 (2003) to 0.68 (2007) to 0.71 (2014) (see **Figure 9.2**). In the past, the transport equipment sub-industry appears to be an unattractive industry in Malaysia due to low industry visibility and lack of business-friendly policies that support the growth of the industry. However, in recent years, this sub-industry has done better in attracting skilled workers with tertiary qualification and industrial experience compared to the national aggregate. For the first time in over 10 years, the human capability index of the transport equipment industry is higher than the Malaysian aggregate in 2014.

The analysis shows that large foreign firms' human capability has remained high from 2003 to 2014. Large local firms increased from 0.8 (2003) to 0.88 (2007) but declined to 0.73 (2014). Local micro and SMEs have also consistently kept their human capability development high. In particular, the local micro and SMEs recorded consistent improvement in human capital from 0.45 (2003) to 0.52 (2007) to 0.7 (2014). This is a positive sign, showing that the Malaysian transport equipment sub-industry is investing significant resources in manpower training to raise the stock of knowledge workers, which is a key factor for enhancing the competitiveness of the industry as a whole.

Figure 9.2: Human Capability of the Transport Equipment Industry

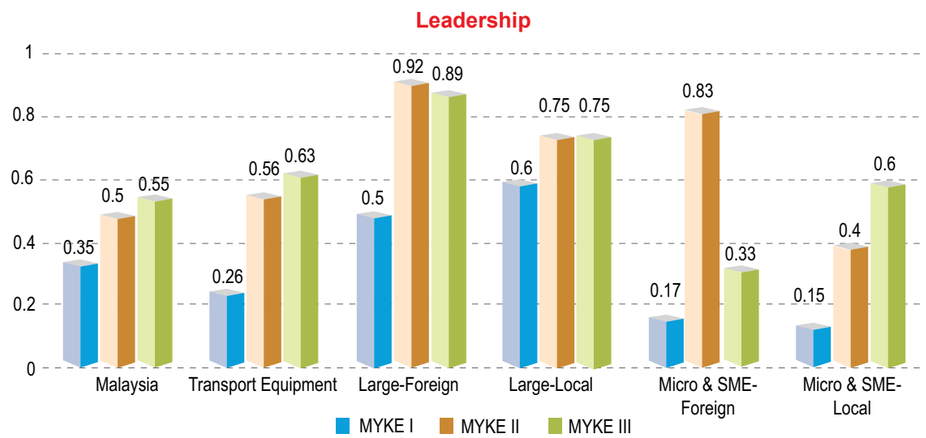


9.3.2 Knowledge Systems and Leadership

As shown in **Figure 9.3**, knowledge-leadership within the transport equipment industry started from a low base in 2003 (0.26), and made some improvements by 2007 (0.56), and rose to 0.63 in 2014. The knowledge-leadership index is above the national aggregate in 2007 and 2014. Large foreign firms leaped from 0.5 (2003) to 0.92 (2007), but regressed to 0.89 (2014). Notably, small foreign firms made a significant improvement from 0.17 (2003) to 0.83 (2007) but fell rapidly to 0.33 (2014). On the other hand, large local firms increased from 0.6 in MYKE I to 0.75 in MYKE II, and stayed the same at 0.75 in MYKE III. Local SMEs recorded a consistent improvement over the years (0.15 in 2003, 0.4 in 2007 and 0.6 in 2014).

Findings from MYKE studies show that foreign firms seem to be moving slowly in instituting formal approaches to knowledge strategy and development. In contrast, through continuous engagement with the Malaysian Government and industry associations such as Malaysian Industry-Government Group for High Technology (MIGHT), Association of Marine Industry of Malaysia and Department of Civil Aviation, the local transport equipment firms have made reasonable progress in formulating knowledge strategy and management.

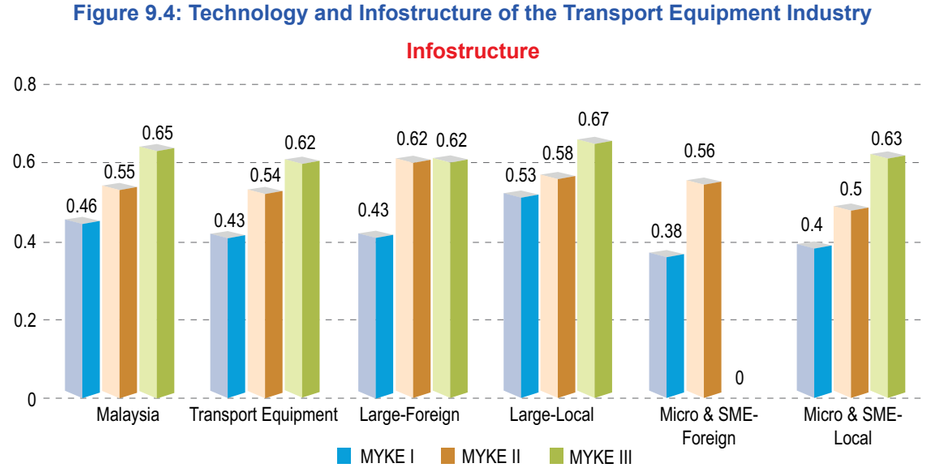
Figure 9.3: Knowledge Leadership in the Transport Equipment Industry



9.3.3 Technology and Infostructure

With regards to technology-based infostructure, the transport equipment industry shows year on year improvement in computer investment and e-commerce usage (see **Figure 9.4**). This is evidenced by consistent increase in the infostructure index, 0.43 (2003), 0.54 (2007) and 0.62 (2014). However, the infostructure index of transport equipment industry is slightly below the national aggregate index. Large foreign firms started at 0.43 in 2003 and plateaued at 0.62 in 2007 and 2014. Local firms made consistent improvement in infostructure, in particular, large firms recorded 0.53 (2003), 0.58 (2007), 0.67 (2014), and small firms registered 0.4 (2003), 0.5 (2007) and 0.63 (2014). Although the transport equipment industry is relatively labour-intensive, the local firms have taken initiatives to upgrade their technology utilisation to improve their manufacturing efficiency and stay competitive in the industry.

Figure 9.4: Technology and Infostructure of the Transport Equipment Industry

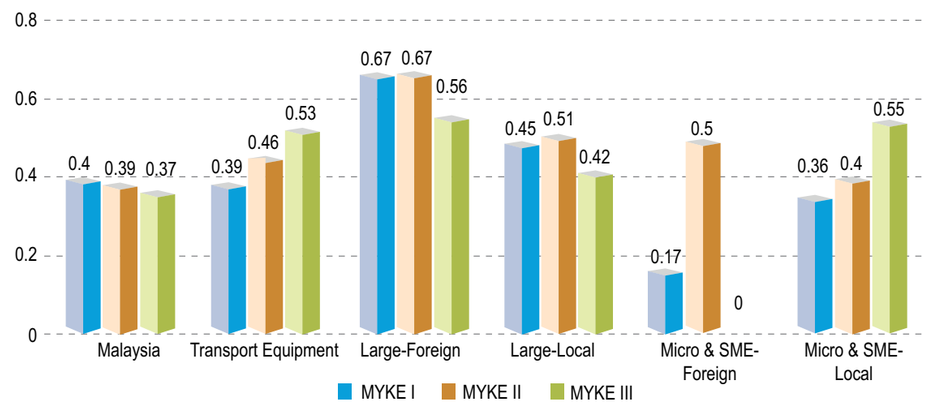


9.3.4 Knowledge Environment

The knowledge environment for the transport equipment industry was found to improve over the three MYKE periods, MYKE I (0.39), MYKE II (0.46) and MYKE III (0.53) (see **Figure 9.5**). The industry's indices were found to be higher than the national industrial average. The trend shows that firms in the transport equipment industry continued to improve their institutional engagement with academia, government, industry and associations.

However, large firms showed an overall decline in the institutional engagement. In particular, large foreign firms declined to 0.56 (2014) from 0.67 (2007). The knowledge environment index for large local firms also declined to 0.42 (2014) from 0.51 (2007). Interestingly, the index for small local firms grew over the three periods from 0.36 (2003) to 0.4 (2007) to 0.55 (2014). This positive result indicates that the local SMEs are gradually expanding their business network to engage with various stakeholders of the transport equipment industry.

Figure 9.5: General Environment Awareness of the Transport Equipment Industry



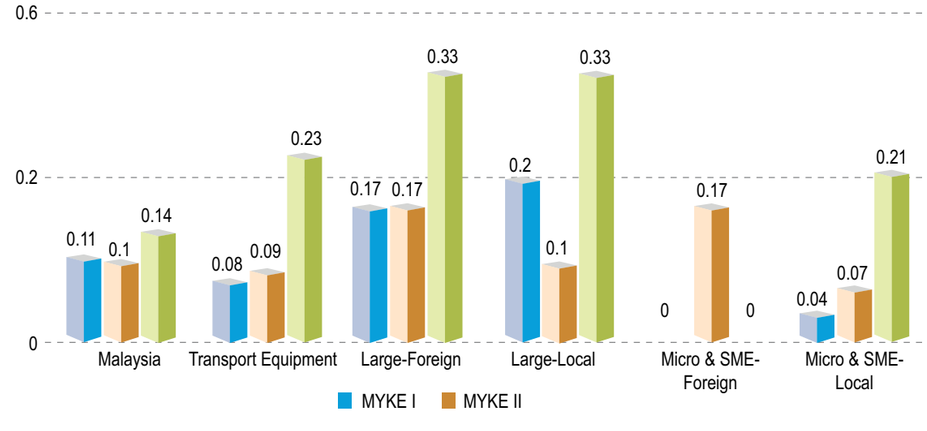
9.4 Knowledge Actions

9.4.1 Knowledge Generation

The knowledge generation in the transport equipment industry improved over the period 2003 to 2014 with an index of 0.08 in 2003, 0.09 in 2007 and 0.23 in 2014 (see **Figure 9.6**). The knowledge generation index of this industry was below the Malaysian aggregate index in 2003 and 2007, but in 2014, the index was above the national aggregate. The major contributors of increased knowledge generation are large firms. Both foreign and local large firms increased from 0.1 in 2007 to 0.33 in 2014. This upward trend shows that the large firms in the transport equipment industry have increasingly committed investment in R&D and intellectual property generation, to remain competitive in the global market.

More notably, local SMEs consistently improved their R&D activities and intellectual property generation, as evidenced by 0.04 (2003) to 0.07 (2007) to 0.21 (2014). This positive progress shows the growing realisation of the importance of R&D, patents and copyright protection among the local SMEs. This reflects the Malaysian government's initiatives such as the Third Industrial Master Plan (IMP3) and National Aerospace Blueprint in harnessing the transport equipment sector are bearing fruit.

Figure 9.6: Knowledge Generation Activities in the Transport Equipment Industry



9.4.2 Knowledge Sharing

Knowledge sharing in the transport equipment industry is marginally higher than the Malaysian aggregate index. The industry's knowledge sharing index incrementally improved over the period from 2003 to 2014 with an index of 0.4 (MYKE I), 0.49 (MYKE II) and 0.53 (MYKE III) (see **Figure 9.7**). Looking at the firms' performance, large firms exhibit a decline in knowledge sharing activities. Large foreign firms declined to 0.56 (2014) from 0.75 (2007), and large local firms reduced to 0.42 (2014) from 0.65 (2007). On the other hand, local SMEs have caught up with the large foreign and large local counterparts in sharing knowledge through project teams, online collaboration tools and inter-organisational communications, as evidenced by an increase in the index from 0.28 (2003) to 0.38 (2007) and to 0.56 (2014).

9.4.3 Knowledge Utilisation

Knowledge utilisation in the transport equipment industry shows a mixed trend, starting from a low of 0.35 in 2003, increasing to 0.89 in 2007, but falling to 0.65 in 2014 (see **Figure 9.8**). All firms, irrespective of ownership and size, increased and fell over the period of 2003 to 2014. In particular, large foreign firms dropped to 0.73 (2014) from 0.88 (2007), whereas large local firms decreased from 0.97 (2007) to 0.7 (2014). Small foreign firms reduced to 0.5 (2014) from 0.75 (2007), and local SMEs declined from 0.86 (2007) to 0.64 (2014).

Being a technology-centric industry, the knowledge utilisation in the transport equipment industry remains disappointingly low. To stay ahead in this competitive industry, large and small firms in Malaysia need to apply new knowledge, particularly external and experiential knowledge, and build a strong knowledge base to accelerate the use of more advanced technology.

Figure 9.7: Knowledge Sharing Activity of the Transport Equipment Industry

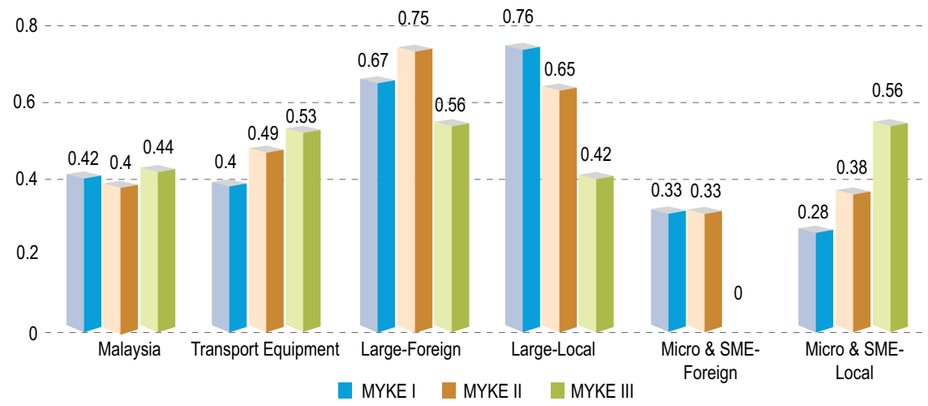
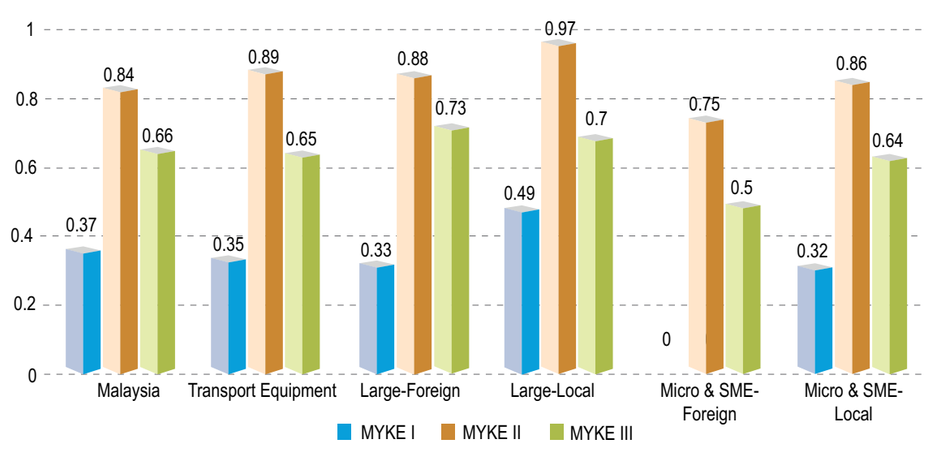


Figure 9.8: Knowledge Utilisation Activity of the Transport Equipment Industry

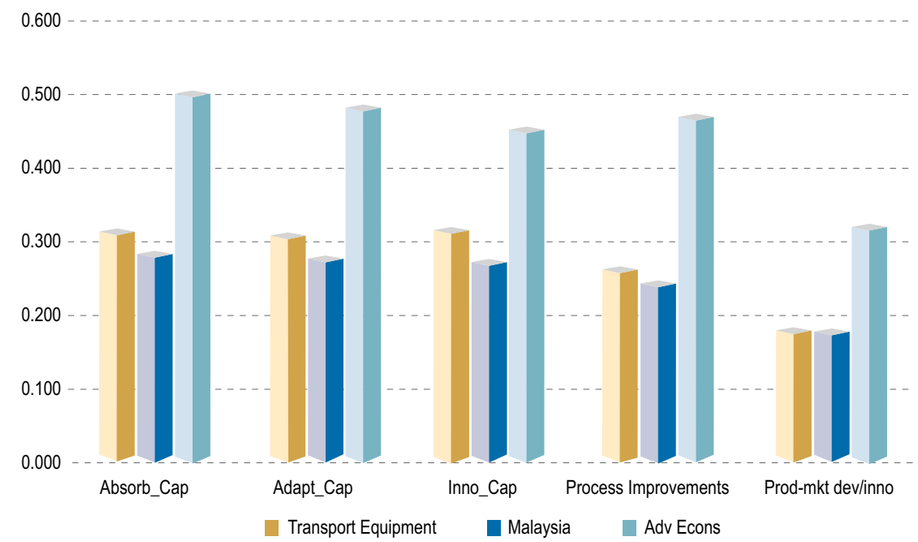


9.5 Dynamic Capabilities Profiles for Transport Equipment Industry

Firms are able to achieve a sustained competitive advantage if they capitalise on their dynamic capabilities and deploy their resources effectively and efficiently. Dynamic capabilities including absorptive capability, adaptive capability and innovative capability are important in enabling firms to develop and reconfigure internal and external competences to respond to the changing environments.

The dynamic capability profile of the transport equipment industry is shown in **Figure 9.9**. It is observed that the transport equipment industry is well ahead of the Malaysian industry average in terms of its absorptive capability, adaptive capability, innovative capability, process improvement and product-market development/innovation. Note that the dynamic capability components for Malaysia were significantly lower than that of more advanced countries. Similar patterns were obtained for process improvements and product market development.

Figure 9.9: Dynamic Capability Profile of the Transport Equipment Industry



9.5.1 Absorptive Capability

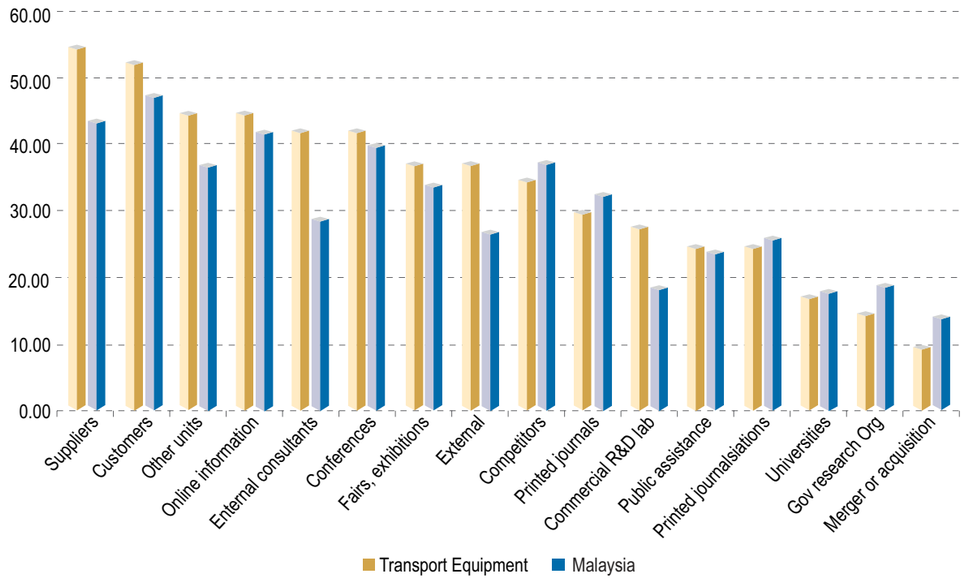
As shown in **Figure 9.10**, suppliers, customers, other organisational units, online information and external consultants are the top five sources of knowledge that the transport equipment firms acquire and utilise. Notably, the knowledge sourcing level is above the Malaysian industry average. This suggests that the transport equipment firms have higher ability than other Malaysian industries of learning from suppliers and customers, recognising the value of external information, and integrating the information into their manufacturing process and operation management. Being in a high-tech industry, transport equipment firms are also actively engaged with external consultants (e.g., from US, Germany, Korea, France and etc.) to improve their knowledge, competencies and skills. However, when compared with the Malaysian industry aggregate, the industry shows lower level of knowledge acquisition from universities, government research organisation and merger and acquisition.

9.5.2 Adaptive Capability

Firms with higher adaptive capability have stronger ability to align internal organisational resources to address the turbulent environment. As shown in **Figure 9.9**, the adaptive capability profile of the transport equipment industry is higher than the national aggregate. This suggests that the transport equipment firms have taken steps to develop human capability.

The skills profile of the transport equipment industry shows that the industry has a large pool of employees trained in business and administration (see **Figure 9.11**). Engineering, and electrical and electronic engineering are the next two groups, followed by computer science and software development. These groups feature at a higher level than the Malaysian industry aggregate. It is expected that the engineering and electrical and electronic engineering have a strong presence in the transport equipment industry, but both groups appear to be below the level of the business and administration. Nonetheless, with the pool of highly qualified workers in transport equipment firms, this industry appears to be a strong industry with high potential to move up the value chain.

Figure 9.10: Sources of Knowledge in the Transport Equipment Industry



Skilled and experienced employees are the greatest asset of transport equipment firms. In Malaysia, the transport equipment industry is strongly supported by several human capability and skill building programmes offered by the government and other institutions. Examples include the Malaysian Industry Government Group for High Technology (MIGHT), Performance Management & Delivery Unit of the Prime Minister's Department (PEMANDU), Malaysian Investment Development Authority (MIDA), German-Malaysian Institute (GMI) and etc.

To stay ahead in a rapidly evolving technological industry, the transport equipment firms are particularly focused on training and education to develop employees' core skills, almost double the Malaysian industry average (see **Figure 9.12)**. This industry also invests more than other industries in facilitating services on finance, accounting and taxation, market development, product and process improvement, standards and technical requirements, quality and research commercialisation.

Figure 9.11: Skills Profile of the Transport Equipment Industry

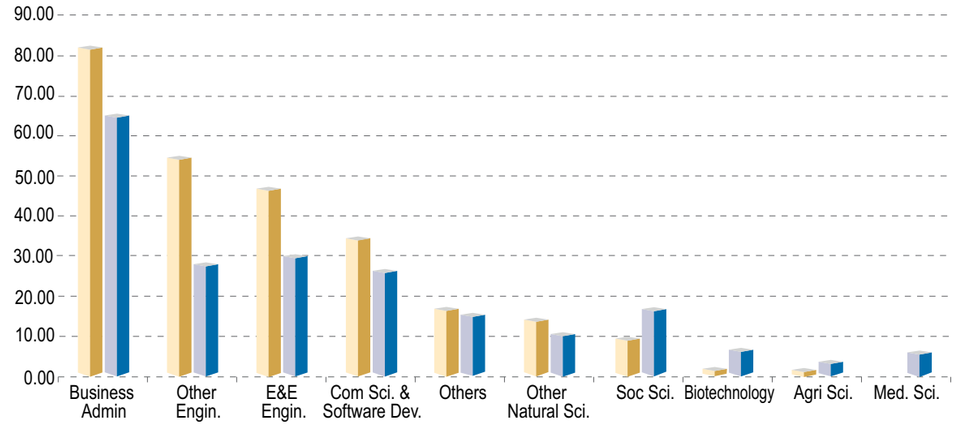
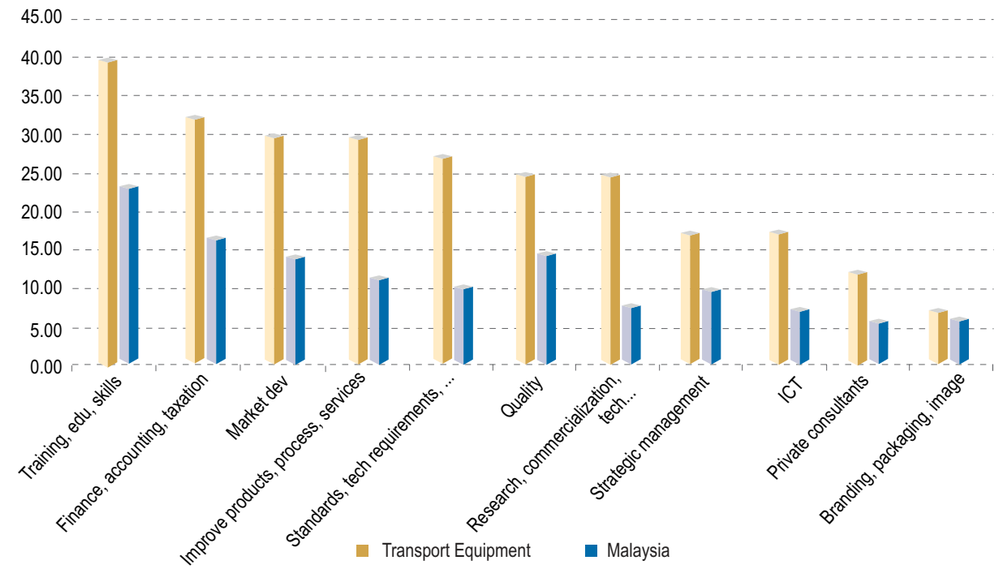


Figure 9.12: Role of Institutional Environment in Skill Building of the Transport Equipment Industry



9.5.3 Innovative Capability

Innovative capability is the third element that translates absorptive and adaptive capabilities into positive organisational performance. Firms with higher innovative capability have a stronger ability to develop new products through aligning strategic goals with innovative management.

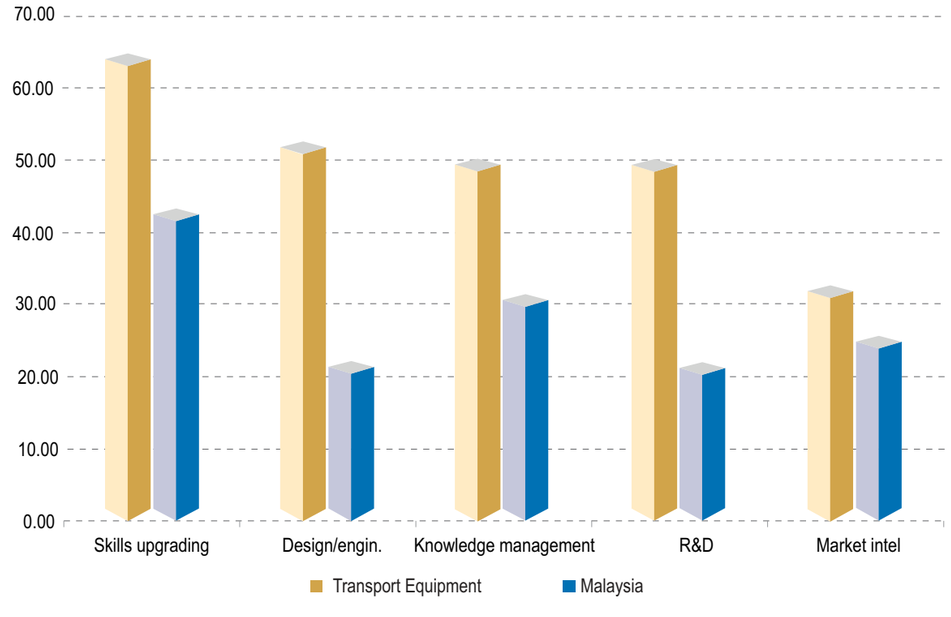
Figure 9.13 shows that the Malaysian transport equipment industry is engaged in a much higher level of innovative capability building initiatives compared to the Malaysian industry aggregate. Specifically, the transport equipment firms are more than double the Malaysian industry average in terms of the level of investment in design and engineering, research and development. These investments move the industry along a more positive trajectory as design and engineering, research and development have become more important in the transport equipment industry in the face of intense competition and rapidly changing market requirements. Moreover, this high-technology industry also shows higher levels of skill upgrading activities, knowledge management and market intelligence, as compared with the Malaysian industry aggregate.

9.6 Outcomes of Dynamic Capabilities in the Transport Equipment Industry

The transport equipment industry is primarily operating within the domestic market, with 76% of its revenue generated from within Malaysia. The survey showed that major revenue for the industry comes from the within the state (50.36%) and followed by national (25.64%). The export sales of this industry is 24%, which includes international sales (19.21%) and 4.79% to regional countries in ASEAN, Japan, China and South Korea. The above analysis is not surprising as the primary focus of the Malaysian transport equipment firms is to provide services to a wide range of industries including the domestic logistics, defence and security sub-industry within Malaysia.

The 'Reactor-Defender-Analyser-Prospector firm' classifications can be used to assess the levels of dynamic capabilities developed to respond to the market demand. **Figure 9.15** shows that there is a strong presence of Defenders (45%) and Reactors (37.5%) firms in the transport equipment industry.

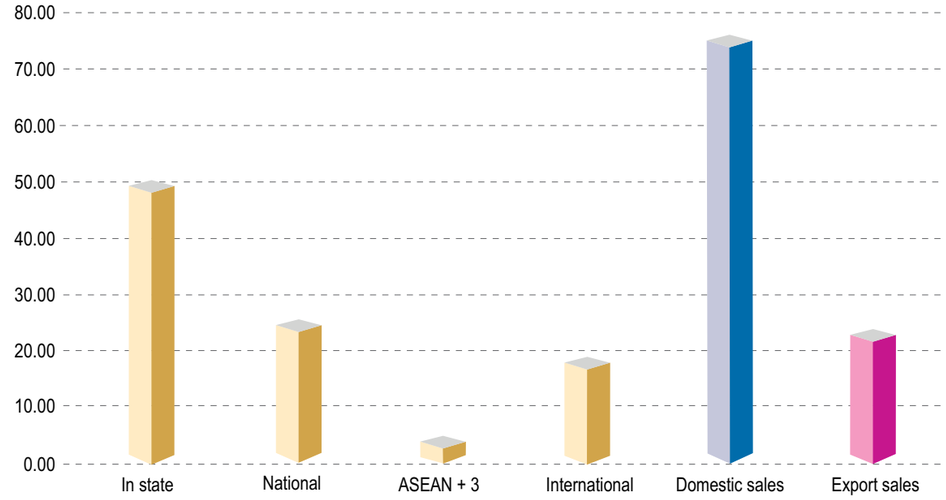
Figure 9.13: Knowledge Intensive Activities in the Transport Equipment Industry



The average of Analysers firms is disappointingly low, constituting only 2.5%. However, it is observed that the transport equipment industry has slightly more Prospectors (15%) firms than the Malaysian industry aggregate.

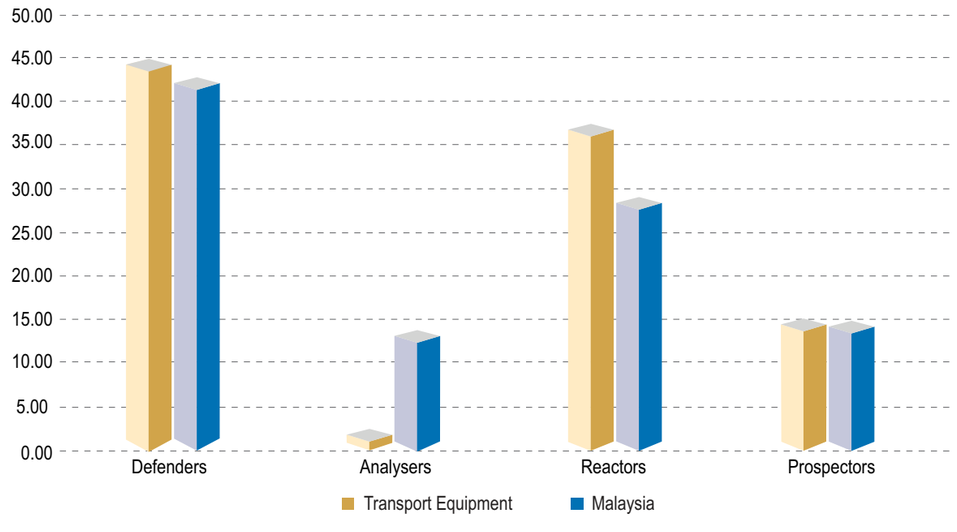
The strategic profile of firms suggests that the transport equipment industry is led by the Defenders and Reactors firms. Only a small number of firms are Analysers and Prospectors, indicating an urgent need to encourage the industry to develop higher levels of environmental determinism and strategic choice in pursuit of new product-market opportunities.

Figure 9.14: Market Presence of the Transport Equipment Industry



Note: The results are based on survey data.

Figure 9.15: Strategic Profile of Firms in the Transport Equipment Industry

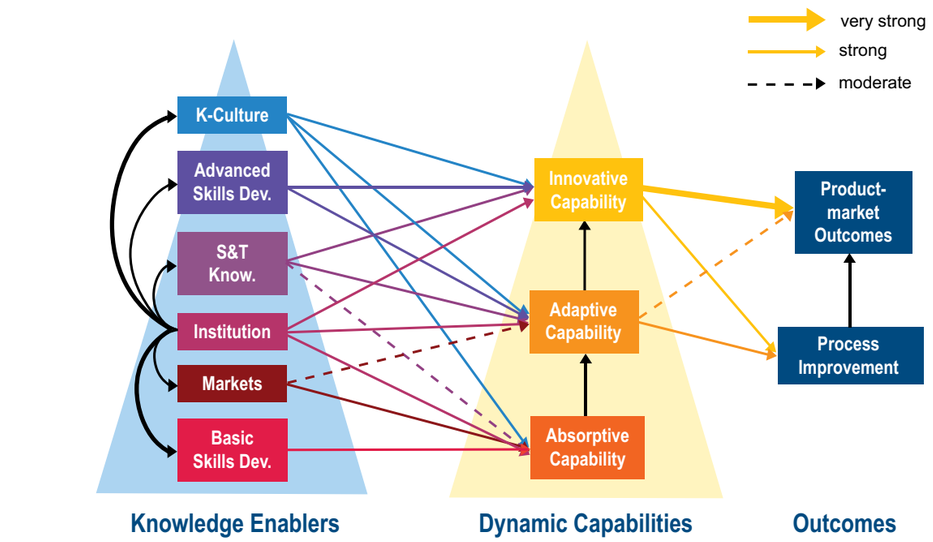


9.7 Relationships between the Key Blueprints of the Transportation Equipment Knowledge Ecosystem

The dynamics between the knowledge enablers, dynamic capabilities and economic outcomes for the transportation equipment industry are discussed in this section. The Malaysian transportation equipment industry's knowledge ecosystem was benchmarked against their counterparts in advanced countries (China, France, Germany, Japan, South Korea and USA). Based on content analysis and the data obtained from DOS, this industry in advanced countries and in Malaysia is classified as an imitator, key industry that has relatively low knowledge content.

Figure 9.16 and **Figure 9.17** show the knowledge ecosystems for advanced countries and Malaysia, respectively. Detailed analysis of the blueprints of the ecosystem for the advanced countries and Malaysia is discussed in **Table 9.1.**

Figure 9.16: Knowledge Ecosystem of the Transport Equipment Industry in an Advanced Country



Note: Very strong impacts are represented by the bolded line, strong impacts are represented by normal lines and moderate impacts are represented by dotted lines.

Figure 9.17: Knowledge Ecosystem of Transportation Equipment Industry in Malaysia

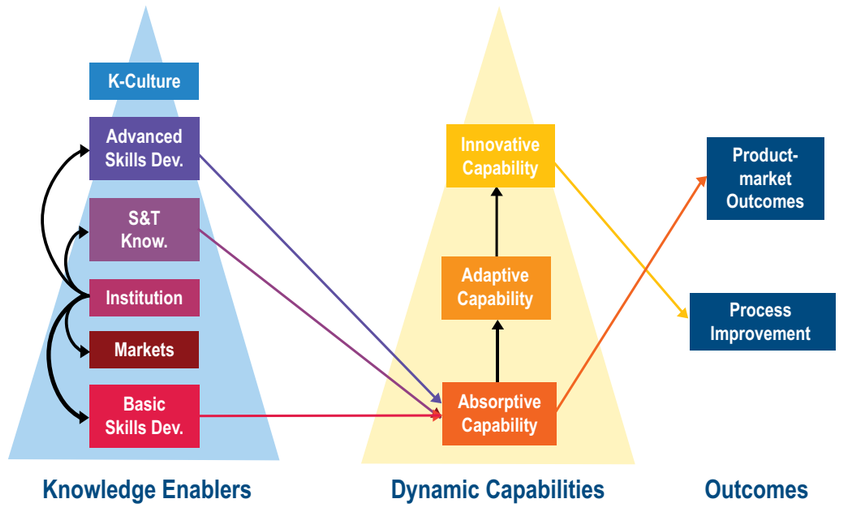


Table 9.1: Knowledge Enablers and Dynamic Capabilities for the Transportation Equipment Industry

Advanced Countries	Malaysia
Basic Skills have a **positive and strong impact** on absorptive capability. These countries invest significant resources in developing STEM related areas and for continuous upgrading of skills and training. These countries also host very strong auto industries and complement the transport equipment industry. The TEVT education system is well developed and works closely with industry to ensure the training and development are aligned to the needs of the industry.	Basic Skills have a **positive and strong impact** on absorptive capability. Provision of primary skills development programs involved in OEM related operations - assembling, servicing, component parts & accessories and repairing transport equipment. However, the basic skills are significantly lower than the selected advanced countries. This industry lacks a local workforce and relies on foreign workers.
Market Intelligence has a **positive and strong impact** on absorptive capability; and positive and moderate impact on adaptive capability. The industries in these countries have very sophisticated mechanisms to ascertain feedback and obtain information from suppliers, customers, competitors, R&D centres and other key network partners. These countries also have trade offices and economic attaches provide valuable insights on market information. The information is translated into knowledge using advanced market analytics for strategic decision making at all levels of the production value chain.	Market Intelligence has **no impact** on dynamic capabilities. Majority of local firms do not invest in sophisticated mechanisms and tools to obtain market intelligence to enhance their dynamic capabilities. There is a tendency to rely on foreign suppliers of technology for product information and knowledge – hence, the firms do not move up the knowledge and innovation value chain. There is an over reliance on the government for projects and this hinder innovative capabilities and competitiveness of this industry.

Table 9.1: Knowledge Enablers and Dynamic Capabilities for the Transportation Equipment Industry (cont'd)

Advanced Countries	Malaysia
Institutions are **strong enablers** of the knowledge ecosystem and have **direct strong and positive impact** on all three dynamic capability components. Institutions such as research institutes, universities, regulators and trade associations play a role in enhancing the level of knowledge content and capabilities of the transport equipment industry, as it is one of most sophisticated high technology intensive industry. In these countries, specialise institutions have been established to undertake cutting-edge R&D and disseminate this knowledge across a range of institutions, starting from technical schools, colleges, polytechnics, universities, GRIs and industry laboratories. Systematic and holistic STEM related manpower training program related to the transportation equipment industry with the support of all stakeholders have enhanced the dynamic capabilities of the industry. For example, The Korea National University of Transportation (Korea National University of Transportation, 2010) is a dedicated university for developing next generation transportation equipment that are globally competitive.	Institutions **strong enablers** for all the other knowledge enablers, but **does not impact** the k-culture and three dynamic capability components directly. While most of the institutions (government, industry associations universities and research institutes) are important players for developing the environment for the transport equipment industry, these institutions do not improve the dynamic capabilities of the industry. Plagued by a shortage of experts and talent in the field; lack of strong universities, research centres and industry players in the field; and over-reliance on government projects, dynamic capabilities in the industry are hindered.
Science and technology knowledge has a p**ositive and moderate impact** on absorptive capability; but, p**ositive and strong impact** on adaptive and innovative capability. In the advanced countries, the S&T base is very strong and the transportation equipment industry is one of the key priority industries, where significant resources are channelled into R&D and translational research. Resources are invested to continuously upgrade the S&T infrastructure and expertise, which enable these countries to raise the standard and quality of the products. Significant resources are also invested to build and sustain strong global brands that have wide market reach and richness in the spectrum of product offerings – that increases the variety and shortens the product cycle.	Science and technology knowledge has a p**ositive and strong impact** on to absorptive capability only. The S&T base in the country is still developing. Hence, much of S&T is to develop absorptive capability to innovations from more developed countries. The absorptive capabilities have opened new opportunities for the industry to be an important and assembler of transport equipment and service centres for major carriers and industry players in the region.

Table 9.1: Knowledge Enablers and Dynamic Capabilities for the Transportation Equipment Industry (cont'd)

Advanced Countries	Malaysia
Advanced Skills have a **positive and strong impact** on both innovative capability and adaptive capability. In the advanced countries, the STEM education and R&D are very strong. This is supported by a very strong basic research and translational research culture. There are significant spill over benefits and knock-on benefits from STEM research in other fields to the transport equipment due to strong inter-disciplinary and multidisciplinary research teams and programs. Government support programs such as Small Business Innovation Program and other extension programs plays a key role in knowledge and technology transfer to industry, especially SMEs. These initiatives close the 'knowledge-commercialisation chasm', and help raise the adaptive and innovative capability of firms in the transport equipment industry.	Advanced Skills have a **positive and significant impact** on absorptive capabilities only. STEM interdisciplinary and multidisciplinary research is still in its developing stage. Hence, much of the advanced skills developments are from major technology partners as opposed to home-grown players or institutions. There are no major local players in the transport equipment space that undertake leading R&D activities. Hence, the advanced skills acquired are to use high technology from more advanced countries to improve productivity and efficiency – that is to improve absorptive capabilities. These absorptive capabilities have led to Malaysia being important service providers for major international players in the region.
Knowledge culture has a **positive and strong impact** on all three dynamic capabilities. The industry is supported by a very strong S&T base in these countries. As such, the transport equipment industry is high-tech and use very advanced knowledge management systems to develop, design and disseminate new innovations via the value chain across using various platforms and champions (government agencies, GRIs, GLCs, universities, training institutes, industry associations and industry). There is concerted effort by all parties to develop an efficient and sophisticated supplier network and supply chain. As such, efficiency of information and knowledge flows to all stakeholders in the supply chain are critical. This is further supported by sound capability development program to enhance all three dynamic capability components.	Knowledge culture has **no impact** on the three dynamic capability components. The S&T base in the country is still in its infant stage of development and this to some extent determines the state of play of the local transport equipment industry and the level of competitiveness of the local players in the industry. The local transportation equipment cluster is still in its early stage of development and information and knowledge flows are relatively patchy and uncoordinated. Stakeholder priorities supersede that of the broader industry of developing and strengthening existing cluster. Only the larger firms with advanced technology and systems are able to develop the knowledge culture that enhances the dynamic capability components. Very little knowledge transfer takes place between large foreign MNCs to local players. Most of the local players are dependent on foreign technology ('lock-in') with very little know-how and capability to move up the innovation value chain.

Table 9.1: Knowledge Enablers and Dynamic Capabilities for the Transportation Equipment Industry (cont'd)

Advanced Countries	Malaysia
The continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** In the advanced countries, where the transport equipment industry has been identified as a priority industry, there are clear plans to raise the level of dynamic capabilities by investing in appropriate infrastructure development, talent development strategy, institutional reforms to foster greater engagement and participation in strengthening the transport equipment cluster. In essence, there are clear long-term strategy put in place to continuously improve the transport cluster via ensuring upgrading of skills and talent needed for the industry – the strong supplier network demonstrates that absorptive capability is an important foundation for the industry to build adaptive capability. Further, strong adaptive capability is also an important support for innovative capability of workers in the transport equipment industry.	The continuum from absorptive capability to adaptive capability to innovative capability **is present.** The transportation equipment industry is a high-tech industry in Malaysia and is dependent on foreign players for the core technologies. Increasingly, over the years, the level of sophistication among local players have been increasing and many of them service providers for most for global industry players – they are part of the global supply network in providing services and support to foreign firms. The movement from absorptive to adaptive to innovative capabilities reflects the increasing levels of the local transport equipment industry becoming an important regional service centre for major global carriers and industry players.

The impact of dynamic capabilities on economic outcomes in the transportation service industry is summarised in **Table 9.2.**

Table 9.2: Dynamic Capabilities and Economic Outcomes for the Transport Equipment Industry

Advanced Countries	Malaysia
Adaptive capability has a **positive and strong impact** on process improvement and a **positive and moderate impact** on product market development. The transport equipment industry undergoes rapid changes and is highly competitive. Firms in this industry invest significant resources to continuously adapt new technologies and knowledge to improve the quality of their technology and services. In some instances, there is cooperation among major players to undertake joint-venture initiatives to adapt new technologies from one another to develop products and services. These initiatives lead to process improvements and new product development in the transport equipment industry.	Absorptive capability has a **positive and strong impact** on product market development. A majority of locals firms are recipients of foreign technology and 'know-how'. Using foreign technology, the local players develop products and services to cater for the domestic market. Some of local firms (mostly the larger firms) are globally competitive in producing parts and components and become suppliers for foreign global players.

Table 9.2: Dynamic Capabilities and Economic Outcomes for the Transport Equipment Industry (cont'd)

Advanced Countries	Malaysia
Innovative capability has a **positive and strong impact** on process improvement and a **positive and very strong** impact on product market outcomes. This is a highly competitive industry and countries that focuses on developing this industry invest significant resources into R&D in STEM related areas; and translational research and innovations for transportation equipment industry. Strong partnership between all stakeholders leads to process improvement and product development. Among the biggest users of this new innovations are the governments in these countries – a strong domestic market provides a strong foundation for firms to pursue a strategy of internationalisation.	Innovative capability has a **strong impact** on process improvement only. Innovative **does not impact** product market outcomes. Most of the local firms are over-reliant on foreign players for core technology. Due to their lack of ownership of IPs and patents, many local firms are unable to create new transport equipment for the international market. Using core technology from foreign technology partners, most local firms develop products that are more cost efficient for the domestic market. Some local firms become suppliers of services to foreign players -an area where Malaysia is gaining some traction is being a service centre for the various modes of transportation in the region.
Process improvement leads to a positive and **moderate impact** on product market outcomes. Many of the advanced countries have a very strong S&T base and strong global brands in the transportation space. They remain globally competitive, most firms strive to continuously improve their products and services. Many invest significant resources to ensure their products are eco-friendly, fuel efficient, excellent comfort, improved safety design and other features that extend their products' reach and richness to the global communities.	Process improvement **does not impact** product market outcomes. Many of the local firms are adopters of advanced technology from foreign firms. The local firms are mostly service providers to foreign players. Lack of technological capabilities, low ownership of IPs and few commercialisation opportunities hinder local firms from creating new products from home-grown innovations. The domestic market is too small for firms to gain economies of scale and scope. Many of the local firms prefer to be suppliers and service providers for larger foreign players.

9.8 Summary: Key Trends, Challenges, Way Forward and Best Practices

9.8.1 Industry Trends

The transport equipment industry is one of the important pillar industries of the national economy. In spite of the challenging nature of the industry's operating landscape, the transport equipment firms were able to improve their productivity as a result of stronger dynamic capabilities which was made possible through the nation's transformation plans and initiatives, technology investment, industry collaborations and human capital development. Within the 21 economic sectors in Malaysia, the transport equipment industry possesses a strong absorptive capability, adaptive capability and innovative capability. More importantly, the industry's positive position in dynamic capabilities has resulted in process improvement in manufacturing transport equipment and higher level of product-market innovation.

Although the level of knowledge content and dynamic capability of the Malaysian transport equipment firms is relatively high, the firms face intensive competition from regional countries such as Japan, Korea China and Singapore. The *2015 Review of the Maritime Transport* states that Malaysia is ranked 25nd in number of vessels of 100GWT and above; while Japan, China, Singapore and Korea are ranked 2nd, 3rd, 5th and 6th, respectively. The report state that Malaysia accounts 0.93% of the global market share, while Japan, China, Singapore and Korea account for 13.30%, 9.08%, 4.84% and 4.62%, respectively. In 2014, 91.3% of the ship building was undertaken by three countries – China (35.9%), Korea (34.4%) and Japan (21%).

Many of the firms from these countries have greater economies scale and scope; and with greater liberalisation in the region, domestic firms will face direct competition with more innovative and technology-savvy foreign firms operating in the domestic market and regionally. To remain competitive, domestic firms need to actively improve their knowledge intensity and quality of products and services.

In line with the government aspirations, the Malaysian transport equipment industry should strengthen its organic growth and seek out new avenues to compete in the global market. Some of the key challenges and ways forward are discussed in the subsequent sections.

9.8.2 Challenges

The transport equipment industry is increasingly becoming an important industry for Malaysia, as trade and commerce intensify in the ASEAN region. The increasing movement of goods and people via the different modes of transportation in the region over the last decade has increased the demand for more efficient transportation technology and services. While increasing growth for more efficient transportation services opens new opportunities for the local transport equipment industry, the industry continues to experience a number of challenges that hinder its position from being competitive. These challenges are discussed below.

Institutions:

- While the transport equipment industry has the potential to leverage on the local auto industry, weak collaboration between the various institutions (government agencies, industry associations, university and industry) hinders strategic development.
- The transport equipment clusters are fragmented and not well linked with other clusters such as the machinery & instrumentation, automotive, education and training. In other words, there is a lack of coordination across the different industries that complement one another.
- Trade associations' interest are primarily dominated by larger firms, who use the platform to lobby for rent-seeking government incentives rather than sharing of knowledge among the members. Associations are primarily a forum to voice grievances.

Basic Skills Development:

- The industry is a high-tech industry. Most firms rely on foreign technology and expertise from advanced countries (e.g. shipyard, imported machinery and equipment).
- Primary skills development is concentrated at operational skills (assembling, servicing, component parts and accessories repairing).
- A serious shortage of local workers due to 3D status jobs. Hence, the industry is reliant on foreign workers willing to work more for less.

Advanced Skills Development:

- The industry is transforming at a rapid pace due to technological development. However local institutions have not build expertise in the field and lag behind global players.
- Weak collaboration between educational/research institutions has resulted in course curriculum and training programs that fail to meet the needs of the industry.
- Lack of expert mentors and high cost of training hinder many SMEs from accessing high-tech courses and training program.
- Local firms develop facilitative programme to support external acquisition of knowledge, but do not have effective knowledge transfer strategies.
- No major local player is undertaking leading R&D in the transport equipment areas.

S&T Knowledge:

- Currently, S&T knowledge is acquired through joint ventures with foreign companies (e.g. Korean and France technology).
- Most R&D is incremental contextualisation of technology for the local environment.

Market Intelligence:

- Information obtained and gained from scanning the market is not significant in enhancing dynamic capabilities. Vast majority of market information is obtained from information technology partners, creating a culture of heavy reliance on foreign technology and innovation.
- The industry focuses on "sell and build", not "build to sell".
- Over reliance on government for projects and opportunities.
- Institutions are not investing in appropriate resources to undertake regular market intelligence, which is much needed in a highly competitive and rapidly changing global landscape.

Knowledge Culture:

- Local S&T culture is developing. However, the local industry remains primarily assembly based and fails to adequately develop indigenous innovations.
- Firms are risk averse in investing in frontier technology due to lack of global market presence and technical capability.
- Rampant talent poaching discourages firms from investing in a knowledge culture within the organisation.
- Most local firms, especially SMEs adopt a hierarchical organisational structure, which stifles creativity.

9.8.3 Way Forward

The transportation equipment industry is an important driver for the logistics and supply chain industry. To ensure that the industry moves up the innovation and knowledge value chain, the following practices are recommended.

Recommendation 9.1: Focus Development on Frontier Technology for a Smart Intelligent Transportation Ecosystem (SITE)

- Leverage on the strong automobile and the manufacturing industries in Malaysia - resources should be channelled to develop key technology platforms that will spearhead the domestic transportation equipment industry.

- R&D activities and translational research should be focused in frontier technology such as: lowering carbon emission and 'green-transportation technology'; advanced and composite materials for next-generation vehicles; Smart Self-driving vehicles (SSDV) that are connected using advanced communication technology that not only improves quality of driving and safety but also intelligent transportation and logistics systems for all modes of transportation.

- Establish centres of excellence (in the research priority areas mentioned above) in partnership with local industry and leading research institutes from Japan, China, Korea and Germany.

Recommendation 9.2: Create a Competitive and Business Friendly Ecosystem for Smart Intelligent Transportation Ecosystem (SITE)

- High priority should be given to developing a competitive indigenous transport equipment industry by providing financial support and outreach and training programmes for local firms, similar to the Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programs in the USA, to stimulate innovation in this industry.

- Introduce a Manufacturing Extension Program similar to the type of program in the USA, which provides services to improve their S&T base, workforce, customer relationship, marketing, branding and prototyping & testing facilities. Key universities/colleges across the country can be the locational site providing technical, infrastructure and expert support for the firms located across the country.

Recommendation 9.3: Nurturing Talent and Human Capital Development for the Next Generation - Smart Intelligent Transportation Ecosystem (SITE)

- Comprehensive talent management strategy for this industry must be in place to ensure quantum and quality of professionally trained engineers and technical personnel are available for the industry. The number of colleges and universities providing courses and research programs related to the transportation equipment industry should be increased.

- Accesses to affordable training programs to continuously upgrade the skills set of the workforce should be in place. These programs should be jointly conducted with key colleges/ universities in partnerships with industry, as part of the Manufacturing Extension Program.

Recommendation 9.4: Develop a Sustainable Vendor Development Program to Raise the Dynamic Capabilities of SMEs

- Strengthen the vendor development program to assist SMEs gain access to training, technology and support to improve their quality standards; improve speed of delivery; reduce cost of production; and diversify their production processes to cater for a wide range of transport equipment manufacturers and global supplier network.

- The vendor development program should cover all segments of the value chain – the System Integrators, Global Standardiser-Systems Manufacturers, Component Specialist and the Raw Material Suppliers.

9.8.4 Best Practices

The transportation equipment industry is the backbone of Malaysian transport and logistics. To maintain its competitive advantage in the region, the industry should continuously review its current plans and strategies and incorporate a number of global best practices to strengthen the transportation equipment industry's knowledge ecosystem. The discussion below provides some of the best practices in more advanced economies.

Best Practice 9.1: Focus Development on Frontier Technology for a Smart Intelligent Transportation Ecosystem (SITE)

Canadian Aerospace Industry

- A 20-year vision and strategic plan to develop the industry to be globally competitive (National Aerospace and Deference Strategic Framework).

- A strategic industry for enhancing the knowledge intensity of the Canadian economy. It is a major contributor to the economy C$28 billion in 2015, where 27% is from Maintenance, Repair and Overhaul (MRO) services and 73% manufacturing aircraft parts and components.

- Employs 76,000 workers directly of which 47% are skilled employees. The aerospace industry has created 211,000 jobs to Canadian economy.

- R&D investment in the aerospace industry is five times higher than national average R&D spending and 2.5 times higher in productivity growth than the national average.

- Home to major players such as Bombardier, CAE the world's largest flight simulator, turbo shaft (helicopter) engines, Pratt & Whitney Canada.

- 60% of the exports are supply chain related.

- The ecosystem contains around 700 aerospace firms that can provide OEM services, including parts and components manufacturing to major aircraft makers such as Boeing and Airbus.

Best Practice 9.2: Create a Competitive and Business Friendly Ecosystem for Smart Intelligent Transportation Ecosystem (SITE)

Canadian Aerospace Industry

- Strong support from the Canadian government – major buyer of the products and services from the aerospace industry, especially Ministry of Defence.

- Strong support for local suppliers by Canadian-owned aerospace firms – 55% companies in Canada sourced parts from Canada.

- Very strong institutional support for administering and processing IP (Canadian Intellectual Property Office); a strong space program (The Canadian Space Strategy); high visibility of aerospace design and research to the scientific community and students (Consortium for Research and Innovation in Aerospace in Quebec); and access to funding to address global challenges jointly with leading research centres and industry (Global Partnership Program).

Best Practice 9.3: Nurturing Talent and Human Capital Development for the Next Generation - Smart Intelligent Transportation Ecosystem (SITE)

Canadian National Research Council's Aerospace Manufacturing Technologies Centre Montreal, Mirabel – Quebec and Ottawa – Ontario, Canada

- Strategic government funding for basic, applied and translational research is made available through the National Science and Engineering Council of Canada (NSERC) for the aerospace industry to develop, design, demonstrate and implement next generation cost-effective manufacturing methods.
- Key research focus areas include: advanced composite materials and structures; automation; robotics and intelligent manufacturing systems; high-speed and high performing machining; and machining process dynamics and simulations.
- These R&D programs are in partnership with leading industry players.
- Industry is provided access to the state-of-the-art research & testing facilities at the centre.

Best Practice 9.4: Develop a Sustainable Vendor Development Program to Raise the Dynamic Capabilities of SMEs

Bombardier Inc., Canada - Building local suppliers to be competitive in the global aerospace industry

- A transparent vendor development program is in place to assist suppliers who are committed to promoting excellence & innovation in the aerospace industry.
- The suppliers have access to Bombardier's manuals, materials and process specifications, standards, systems and other engineering specifications.
- Bombardier has also contributed to the advancement of best practices in the Aviation and Defence industries. This is documented in the Supply Chain Management Handbook (SCMH) produced by the International Aerospace Quality Group. The best practices are available to all suppliers who are keen to raise the quality of their designs and products (Bombardier, 2016).

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CHAPTER 11

KNOWLEDGE CONTENT OF THE ELECTRICAL AND ELECTRONIC INDUSTRY

CHAPTER 11
Knowledge Content of the Electrical and Electronic Industry

11.0 Introduction

The Electrical and Electronics (E&E) industry has been a key driver of economic growth for the country since the 1980s and remains an important contributor to national wealth. As one of the 12 National Key Economic Areas (NKEAs), the E&E industry receives prioritised government support and investment to ensure it remains globally competitive.

The E&E is classified into four sub-industries: (1) electronic components (e.g., semiconductors, passive components, printed circuit boards, metal stamped parts and precision plastic parts); (2) consumer electronics (e.g., audio visual products such as television receivers, portable multimedia players (PMP), speakers, cameras and electronic games); (3) industrial electronics (e.g., multimedia and information technology products such as computers and computer peripherals, telecommunications equipment and office equipment); and (4) electrical products (e.g., boards, panels and consoles, switching apparatus, lamps, air conditioners, vacuum cleaners, ovens, transformers, cables & wires, primary cells & batteries, solar cells and modules) (Malaysian Investment Development Authority [MIDA], 2016).
E&E industry has contributed significantly to GDP growth, employment and export-led economy. According to MIDA (2016), E&E industry remains the leading sector in the country's manufacturing sector, contributing to the nation's exports (33.4%) and employment (23.7%) in 2014. In 2015, E&E products remain the largest traded items for Malaysia, contributing RM277.9 billion to Malaysia's export products (MITI, 2016). The export products include electrical machinery, apparatus and appliances and parts, office machines and automatic data processing machines and parts, telecommunications and sound recording and reproducing equipment and etc. The major export destinations in 2015 include China (RM43,219 million), Singapore (RM42,497.3 million), USA (RM42,190.5 million), Hong Kong (RM29,339.4 million) and Japan (RM18,383.4 million) (MITI, 2016). At present, the E&E industry contributes close to RM37 billion to the Gross National Income (GNI) of the country, and employs 522,000 workers (CREST, 2015). By 2020, E&E industry is projected to contribute RM90 billion in GNI and 679,000 jobs (CREST, 2015).

Malaysia also imports substantial E&E intermediate inputs. In 2014, total imports for electrical machinery, apparatus and appliances and parts accounts for RM146.77 billion, office machines and automatic data processing machines and parts (RM21.74 billion), telecommunications and sound recording and reproducing equipment (RM20.6 billion) and total exports of electrical and electronic products (RM190.8 billion) (MITI, 2015). The total imports of E&E products accounts for RM201.3 billion in 2015 (MITI, 2016).

11.1 Key Development and Initiatives

The strong E&E industry can be attributed to Malaysia's economic and political stability, as well as good infrastructure and a knowledgeable workforce. In addition, the formation of Free Trade Zones (FTZ) enables Foreign Direct Investment (FDI) and attracted many multinational corporations (MNCs) (e.g., Intel, Sony, Samsung, Panasonic and etc.) to base their business operations in Malaysia. MNCs remain to be the main catalyst in developing the E&E industry in Malaysia.
Malaysia has developed significant expertise in manufacturing various semiconductor devices, high-end consumer electronic and information and communication technology products, by supporting the MNCs' businesses. The establishment of global electronic manufacturing services companies (e.g., Flectronics, Solectron, Plexus and etc.) in Malaysia provides great opportunities for the local companies to learn and engage in their supply chain operations for the machine equipment, manufacturing materials, parts and components, and services (e.g., design, testing and prototyping).

Generally, the local E&E companies are engaged in both the front-end and back-end of the semiconductor supply chain. In recent years, local companies such as Globetronics Technology Bhd and UNISEM (M) Berhad have established themselves as credible exporters of E&E products. UNISEM (M) Berhad is a global provider of semiconductor assembly and test services with about 7,000 employees worldwide. It has plants in Perak, Indonesia, China, Indonesia and USA, and specialises in packaging and testing services related to wafer, lead-frame and subtracted integrated circuit (IC) packaging. Globetronics Technology Bhd. was established in 1991 in Penang, and is a manufacturer of semiconductors, light-emitting-diodes (LED) lighting systems, LED components and modules, small outline components, sensors and optical product, chip carrier quartz crystal products (for the telecommunications and automotive industries) and many more. It operates primarily in Malaysia, Singapore, China and USA. Given the increasing demand for semiconductors, electronic components, communications and computer peripherals, the E&E industry is expected to grow steadily.

The E&E MNCs in Malaysia source most inputs from foreign sources. According to the Malaysia Economic Monitor Boosting Trade Competitiveness Report (2014), such enterprises source less than 40% of their inputs from local companies. In Vietnam, 46% are sourced to local companies, while in China it is 82%. The above information show that the linkage between MNCs and SMEs in Malaysia were low compared to some of the regional economic superpowers. Key factors contributing to low utilisation of inputs from Malaysia include low levels of innovations among Malaysian firms. In Malaysia, the R&D activities are mainly undertaken by the government and MNCs. Although there has been some R&D undertaken by the local universities and research institutions,

research outputs generated by these institutions have little potential for commercialisation. The levels of R&D activities undertaken by SMEs on the other hand are very low entirely. Furthermore, due to limited market access, most Malaysian firms in general do not have economies of scale, as such, the cost of input are relatively higher than some of the regional economies such as China.

To improve growth opportunities and development of the E&E industry, under the National Key Economic Areas (NKEA), E&E was established to facilitate the implementation of 20 Entry Point Projects (EPPs) in priority domains of their industry. These domains are integrated circuit design, silicon production, wafer and cell production, solar modular production, LED and Solid State Lighting, wireless communication and RFID, electrical and home appliances, solar photovoltaic, embedded systems, electric vehicle manufacturing electrical and electronics component manufacturing and nanotechnology. The E&E NKEA initiative is expected to create 56,800 new jobs and contribute RM9.7 billion to the Malaysian GNI.

To promote R&D in the E&E industry, the Collaborative Research in Engineering Science and Technology (CREST) was established in 2012 by the Malaysian Government. Headquartered in Penang, CREST has access to 3,000 researchers within 20 kilometres of its facilities. The organisation's 14 founding members consist of the Northern Corridor Implementation Authority (NCIA), Khazanah Nasional, University of Malaya (UM), and University of Science Malaysia (USM) and 10 leading E&E companies. Together, they champion R&D initiatives through the commitment of funds and expertise. Most notably, the 10 E&E companies have contributed over RM25 billion in capital and have invested close to RM1.4 billion for R&D activities. CREST is also responsible for employing close to 5000 R&D workers for the E&E industry.

In addition to CREST initiative, the Ministry of Higher Education introduced Industry Centre of Excellence (ICoEs) to enhance university-industry relationship, E&E is among the five Industry Centres of Excellence (ICoEs) in University Malaysia Pahang that focuses on strategic development of the E&E industry, including addressing the mismatch between local graduates' competencies and industry needs.

To foster closer collaboration between government agencies and firms in the E&E industry, the Electrical and Electronics Association of Malaysia (TEEAM) was established in 1952. The primary role of TEEAM is to be a strong mediator between the government agencies, statutory bodies and the industry players. TEEAM has about 1700 members and is a key representative association of the E&E industries in Malaysia in the ASEAN Consultative Committee for Standards & Quality (ACCSQ) Joint Sectoral Committee on Electrical & Electronics Equipment (JSC EEE), the Federation of Asian Pacific Electrical Contractors Association (FAPECA), the Ministry of Energy, Green Technology and Water (KeTTHA), Construction Industry Development Board Malaysia (CIDB), Energy Commission (ST), Department of Skills Development (DSD), Department of Standards Malaysia and SIRIM Berhad.

The Malaysian legislations for E&E export equipment include three Acts: 1) Energy Commission Act 2001; 2) Energy Commission (Amendment) Act 2010; 3) Electricity Supply Act 1990 (Amendment 2001). Accompanying these are 9 Regulations: 1) Electricity Regulations 1994; 2) Electricity (Amendment) Regulations 2013 [P.U.(A) 151]; 3) Electricity (Amendment) Regulations 2014 [P.U.(A) 73]; 4) Electricity Supply (Compounding of Offences) Regulations 2001 [P.U.(A) 408]; 5) Licensee Supply Regulations, 1990; 6) Efficient Management of Electrical Energy Regulations 2008 [P.U.(A) 444]; 7) Exemption Under Section 54 [P.U.(B)324]; 8) Exemption Under Section 54 [P.U.(B)342]; 9) Electricity Supply (Exemption) Notification 1994 [P.U. (B) 156]. These policies form the baseline for safety, security or design standards for E&E-centric organisations operating within the country. For waste management, Malaysia enacted the Environmental Quality Act (1974), which came into force on 15 April 1975, to regulate collection and disposal of electrical and electronic waste (e-waste) from industries.

Over the last decade, liberalisation through the ASEAN Economic Community (AEC) and numerous Free Trade Agreements (FTAs) has enabled the E&E manufacturers to expand their business globally. Opening up the region to more active and transparent trade has also exposed the domestic E&E industry to stiffer competition from the rest of Asia, particularly China, Taiwan and Singapore. According to the Malaysia Economic Monitor Boosting Trade Competitiveness Report (2014) published by World Bank, China's share of global E&E exports rose by 7%, whereas Malaysia's fell by about 0.3% for the period from 1999 to 2013.

Although the government has taken proactive measures to maintain the competitiveness of its export-led industries by shifting to solar panels and LED lighting and targeting developing countries such as India and Africa, these new initiatives will take some years to attain positive results. To ensure the domestic E&E remains globally competitive, both the government and industry players must work towards developing an E&E ecosystem that will help existing firms to move up the knowledge value chain and nurture new firms that are capable of creating next-generation E&E products.

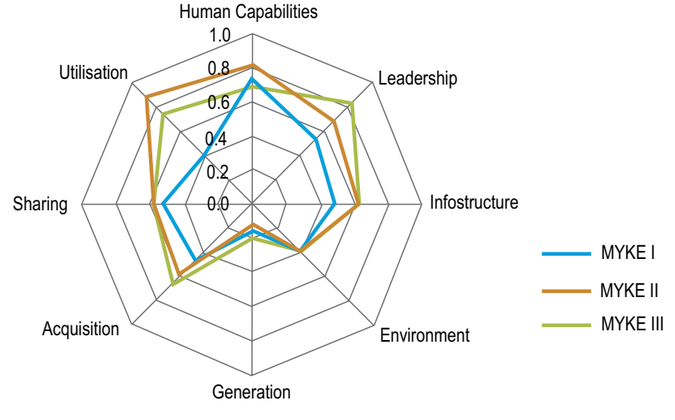
11.2 Knowledge Content

The mapping of the knowledge ecosystem for the E&E industry was based on the following samples for the three MYKE studies, respectively: 120, 123 and 125 as shown in **Table 1.1**. The number of SMEs and large players for the three sample periods were as follows: (SME, Large) are (76, 44); (54, 69); and (49, 76), respectively.

Figure 11.1 shows the results of MYKE assessment on knowledge resource foundations for electrical and electronics (E&E) industry over the period of 2003, 2007 and 2014. Overall, the figure shows positive progress in knowledge leadership, and marginal improvement in both knowledge generation and knowledge sharing. There has been no change in the industry's knowledge infostructure and knowledge environment. However, compared to MYKE II, the period of 2014 shows a decline in human capabilities and knowledge utilisation in the E&E firms.

Figure 11.1: Overview of Knowledge Enablers and Knowledge Actions for MYKE I, MYKE II and MYKE III

Electrical and Electronic



11.3 Knowledge Enablers

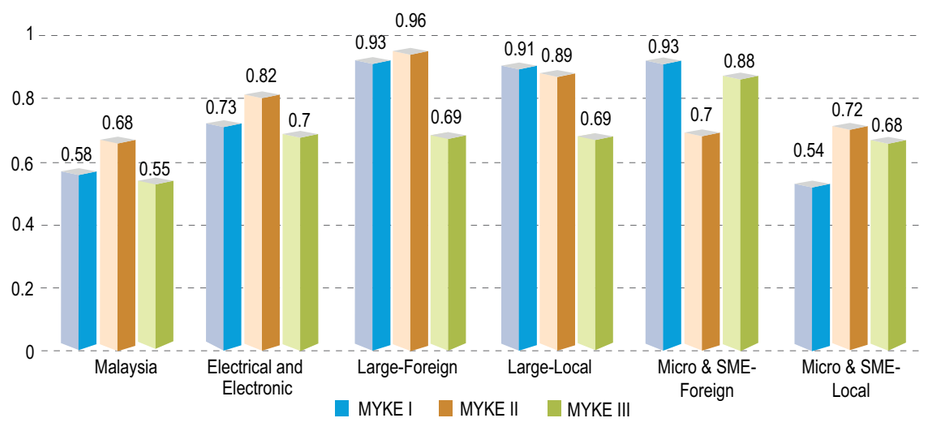
11.3.1 Human Capabilities

Over the period 2003-2014, human capabilities in the E&E industry remain higher than the national aggregate. Further analysis reveals an improvement of the human capability index from 0.73 (2013) to 0.82 (2007) but declined to 0.7 (2014) (see **Figure 11.2**). Evidence shows that large foreign and local firms, as well as the small local firms, are the main reasons of the declining performance. Large foreign firms improved from 0.93 (2003) to 0.96 (2007) but dropped to 0.69 (2014). Large local firms registered a decline from 0.91 (2003) to 0.89 (2007) and subsequently decreased to 0.69 (2014). Small local firms started from a lower base (0.54) in 2003, and made some improvement by 2007 (0.72), but declined to 0.68 in 2014. Interestingly, the small foreign firms were performing better than the large firms and small local firms, with an increase from 0.7 (2007) to 0.88 (2014).

The large E&E firms and small local firms seem to be unable to attract and build human capabilities for their employees. This staffing problem is further aggravated with stiff competition from other countries (e.g., Singapore, Thailand, China and Vietnam) which offers higher salaries and broader work exposure.

Small firms have shown some improvement in human capability, but nonetheless face similar challenge to others in the industry over the three MYKE period.

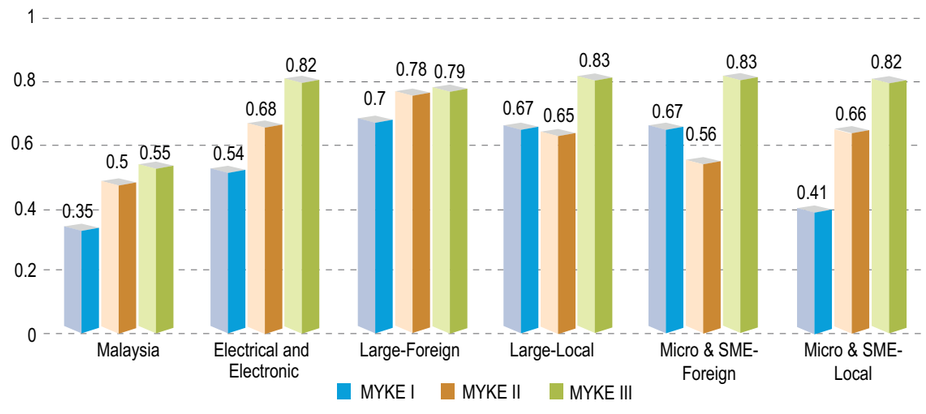
Figure 11.2: Human Capability of the E&E Industry



11.3.2 Knowledge Systems and Leadership

The E&E industry is above the national aggregate in its knowledge leadership dimension. As shown in **Figure 11.3**, there is consistent improvement over the period 2003 (0.54), 2007 (0.68) to 2014 (0.82). There is an increase in overall performance from MYKE II (2007) to MYKE III (2014) for all firm categories. There is no sizeable gap between the large foreign and large local firms in their leadership with regards to the management of knowledge, from acquisition to development and application. Most notably, local large (0.83 in 2014) and small (0.82 in 2014) firms had caught up with their foreign counterparts in knowledge leadership. This shows that some of the initiatives under the various government plans have come to fruition, strengthening the capability of local E&E firms.

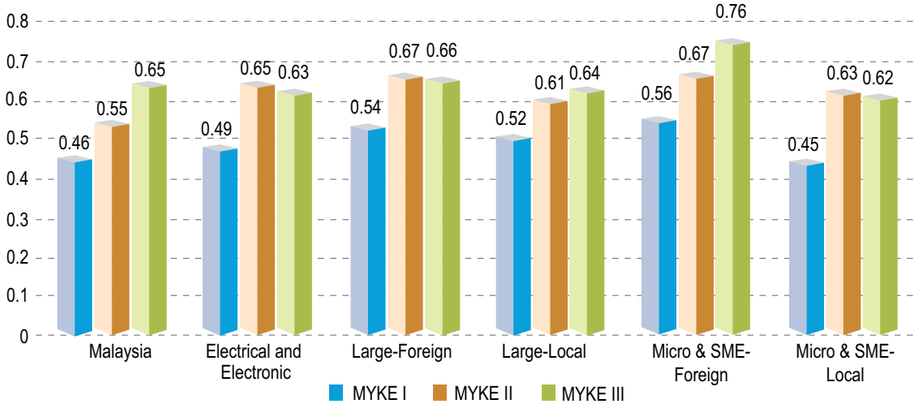
Figure 11.3: Knowledge Leadership in the E&E Industry



11.3.3 Technology and Infostructure

Technology-based infostructure of E&E firms improved from 0.49 (2003) to 0.65 (2007), but slightly decreased to 0.63 (2014), putting the industry at a performance plateau (see **Figure 11.4**). Large local E&E firms have made consistent improvement in their infostructure in terms of computer use and e-commerce adoption, as shown in MYKE I (0.52), MYKE II (0.61) and MYKE III (0.64). Similarly, small foreign firms have increased their infostructure capability from MYKE I (0.56) to MYKE II (0.67) and subsequently to MYKE III (0.76). This result shows that large local and small foreign E&E firms are making larger investments to increase their technology capability to stay competitive.

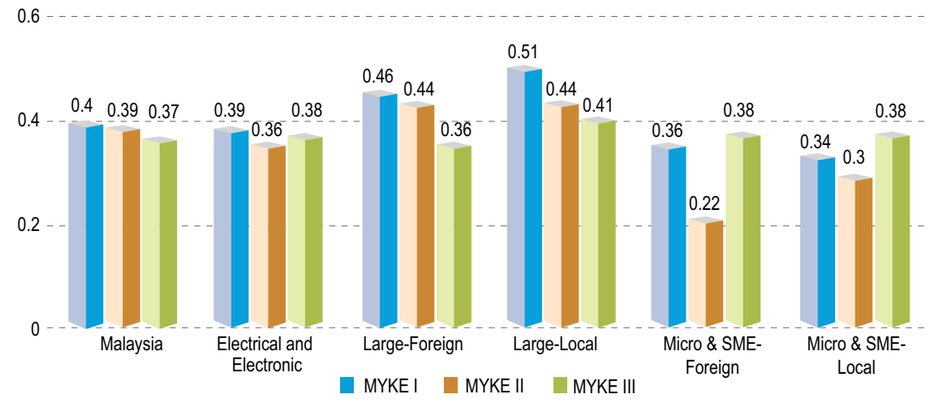
Figure 11.4: Technology and Infostructure of the E&E Industry



11.3.4 Knowledge Environment

In 2003 and 2007, the knowledge environment dimension of E&E firms is slightly lower than the Malaysian aggregate (see **Figure 11.5**). However, the knowledge environment score for the industry is marginally higher than the national aggregate in 2014, being at 0.38 and 0.37 respectively. Unfortunately, large firms declined over the period of 2003 to 2014. Large foreign firms dropped from 0.46 to 0.44 and to 0.36 for the assessment periods, while large local firms slipped from 0.51 to 0.44 and then 0.41. In contrast, the small foreign and local firms had made significant improvements between 2007 and 2014 – a welcome recovery since a sharp decline from 2003 to 2007. Active engagements with industry associations, government, universities and business collaborations have allowed small firms overtake their initial 2003 high. These findings indicate that the local E&E firms, in particular SMEs have reaped the benefits from programmes such as Collaborative Research in Engineering Science and Technology (CREST), TechnoFund, InnoFund and MSC Malaysia R&D Grant Scheme (MGS), to foster the E&E ecosystem in Malaysia.

Figure 11.5: General Environment Awareness of the E&E Industry



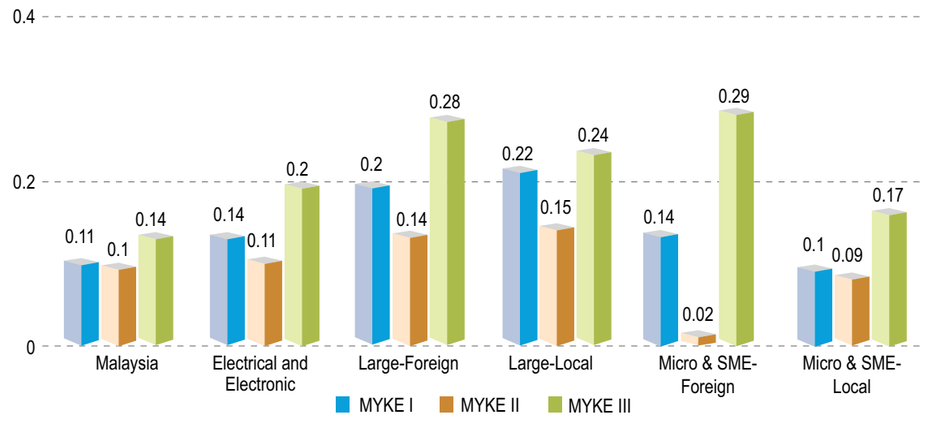
11.4 Knowledge Actions

11.4.1 Knowledge Generation

The knowledge generation in the E&E industry was above the Malaysian aggregate over the period from 2003 to 2014. This is unsurprising as E&E industry is one the key drivers of the Malaysia's economic development. In 2003, the E&E firms registered at a base of 0.14 but dropped to 0.11 in 2007. The decline can be attributed to the reduction of R&D allocations due to the global economic slowdown. In 2014, the knowledge generation index of E&E firms increased to 0.2 (**see Figure 11.6**).

A more detailed analysis shows that there is an increase in MYKE III (2014) across all categories of firms, foreign or local, large or small. Large and small foreign E&E firms had remained reasonably high at 0.28 and 0.29 in 2014. More importantly, large and small local firms had significantly improved from 0.15 to 0.24 (large local) and 0.09 to 0.17 (small local) in 2014, respectively. This is a positive reflection of a higher awareness and protection of intellectual property (IP) as well as the increase of R&D collaboration among universities, industry and government agencies.

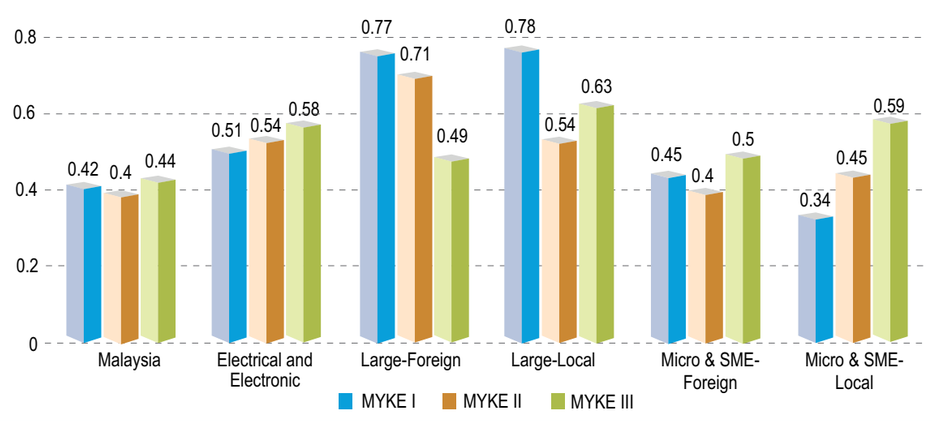
Figure 11.6: Knowledge Generation Activities in the E&E Industry



11.4.2 Knowledge Sharing

Overall, the E&E industry is above the national aggregate in its knowledge sharing dimension. Notwithstanding the improvement pattern in MYKE I (0.51), MYKE II (0.54) and MYKE III (0.58), the levels of knowledge sharing across the firm types differs (see **Figure 11.7**). The local firms exhibit higher knowledge sharing than the foreign firms in 2014. This may be a consequence of the growth of mobile digital and social networking platforms (e.g., smartphone, tablets, Facebook and internal corporate tools) allowing employees to interact and share work knowledge, as well as engage in teleworking and virtual teams. There is a sharp decline in the performance of large foreign firms, from 0.71 (2007) to 0.49 (2014). This may be due to increasing competition in the industry, forcing larger firms to be more careful in sharing knowledge and resources as it may.

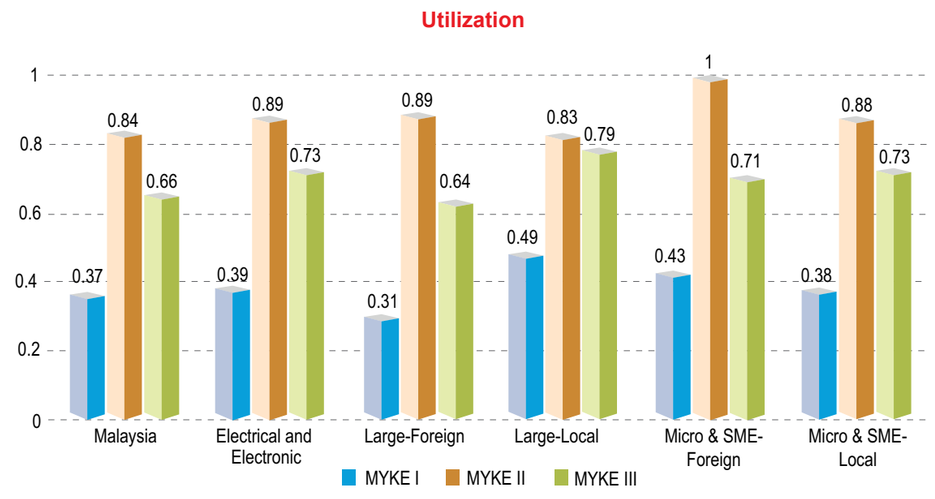
Figure 11.7: Knowledge Sharing Activity of the E&E Industry



11.4.3 Knowledge Utilisation

The knowledge utilisation in the E&E industry is above the Malaysian aggregate. The E&E firms started from a low index of 0.39 in 2003, and significantly increased to 0.89 in 2007, but fell slightly to 0.73 in 2014 (see **Figure 11.8**). Foreign firms show a sharp drop in knowledge utilisation, both large firms (from 0.89 in 2007 to 0.64 in 2014) and small firms (from 1 in 2007 to 0.71 in 2014). The biggest improvement took place within the large and small local E&E firms, registering at 0.79 (for large) and 0.73 (for small), surpassing all the foreign E&E firms. The strong performance of the local firms can be attributed to factors such as higher levels of manufacturing skill and knowledge development of local firms in supporting the multinational companies, availability of collaboration and social business tools (e.g., IBM Domino, Sproutsocial and etc.) that enable local firms to enhance their knowledge and experiences.

Figure 11.8: Knowledge Utilisation Activity of the E&E Industry

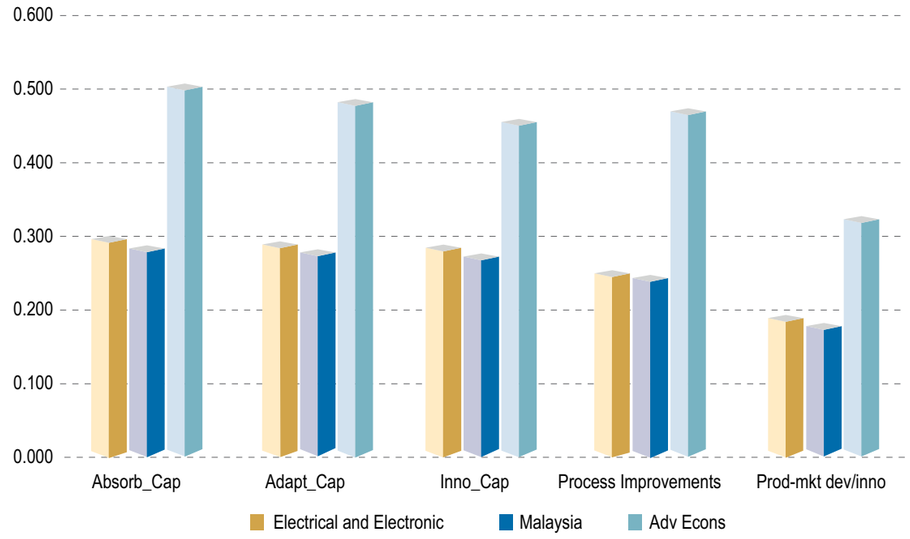


11.5 Dynamic Capabilities Profile for Electrical & Electronic Industry

Firms with higher levels of dynamic capabilities are able to respond to market changes and new opportunities. In this study, dynamic capabilities include three types namely, absorptive capability, adaptive capability and innovative capability.

Figure 11.9 shows the results of Electrical & Electronic (E&E) industry dynamic capability profile, product-market outcomes and process improvement. Product-market outcomes are the level of novelty in innovation - new to the firm and new to the market. On the other hand, process improvements are technologically new or significantly improved internal management or organisational methods that are new or significantly improved marketing concepts/strategies. As a leading industry, E&E has the most liberalised sub-industries in Malaysia's manufacturing industry, the industry performs better than the Malaysian industry aggregate in all areas including absorptive capability, adaptive capability, innovative capability, process improvement and product-market development/innovation.

Figure 11.9: Dynamic Capability Profile of the E&E Industry



11.5.1 Absorptive Capability

Firms with higher absorptive capability have a higher ability of learning from others, incorporating external information and transforming it into firm-specific knowledge. **Figure 11.10** shows that the top three sources of knowledge for E&E industries are suppliers, customers, and online information. This suggests that the E&E industry is customer focused and has built a close linkage of companies with suppliers. It also demonstrates that the E&E firms greatly utilise online information in knowledge capacity building. Learning from both internal units and external sources (e.g., conferences, fairs and exhibitions) is also an important part of the E&E industry's efforts to broaden their knowledge base.

Overall, the E&E industry's absorptive capability is at a higher level than the Malaysian aggregate. Therefore, E&E firms with stronger absorptive capability experience an efficient adoption process leading to positive process improvement and product or market development/innovation, as evidenced in **Figure 11.9**.

11.5.2 Adaptive Capability

An organisation with stronger adaptive capabilities is able to adapt itself through reconfiguring resources and aligning capabilities with environmental changes. One of the key organisational resources in E&E firms is human capital.

Figure 11.11 shows the skills profile of E&E industry. The industry seems to have a good mix of human capability. The graduates from business and administrative disciplines constitute the largest group in the industry. As expected, the industry has a strong composition of employees with an educational background in E&E engineering, computer science, and software development, and these measures are more than double the level of the national aggregate. This result is consistent with the qualitative study, in which participating companies posit that one of the main drivers of E&E industry in Malaysia is the availability of skilled workers.

There is a growing need of research personnel in the E&E industry. Although Malaysia has made efforts to develop employable graduates, more initiatives should be in place to encourage engineers and scientist to pursue Masters and Doctorates through government programs (e.g., MyPhD, MyPhD Industri, and MyMaster). The industry is yet to build a strong pool of talent with research capabilities.

In Malaysia, several institutions and government agencies provide assistance and support to E&E firms that seek help to develop their businesses. **Figure 11.12** shows that the E&E industry is below the Malaysian aggregate in all assistance, except standards and technology development, ICT, and branding, packaging, and image. As presented, most E&E firms seek external services in training, education and skill development. The E&E industry receives assistance in standards and technology requirements above the national aggregate. This is followed by the areas of finance, accounting, and taxation.

Figure 11.10: Sources of Knowledge in the E&E Industry

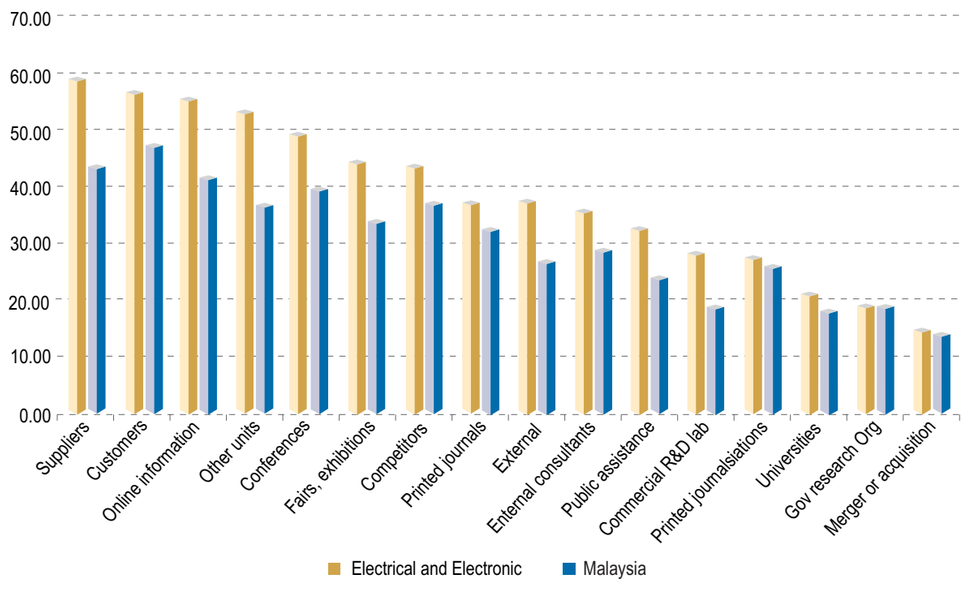


Figure 11.11: Skills Profile of the E&E Industry

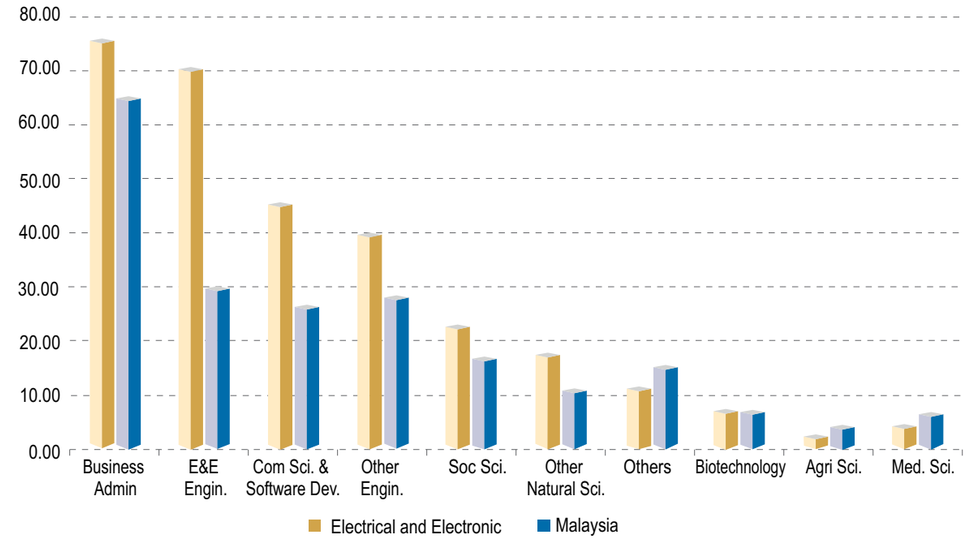
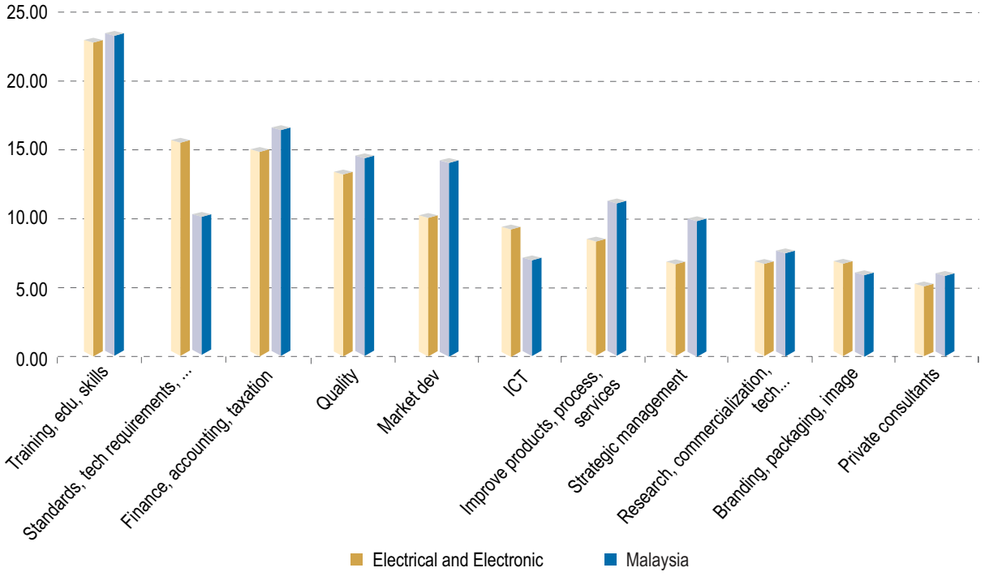


Figure 11.12: Role of Institutional Environment in Skill Building of the E&E Industry

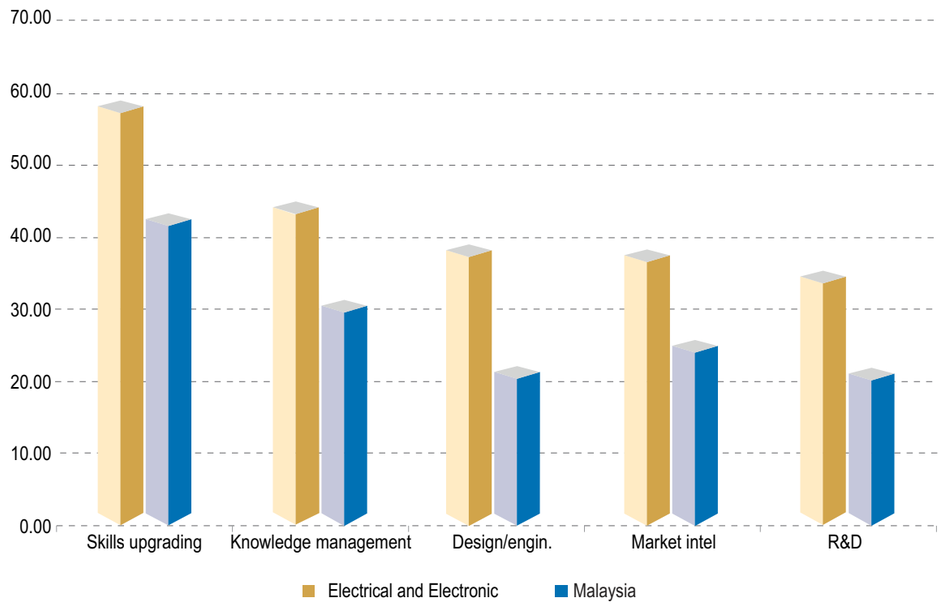


Notably, given that E&E firms are largely involved in export-led businesses, they seek more support in ICT and branding, compared with the national aggregate. An initiative called the GoEx program under the SME Master Plan was designed to help local SMEs to be more competitive in the international market. E&E industry is one of the targeted eight beneficiaries of GoEx. More recently, MATRADE provided support for Malaysian E&E mid-tier companies (MTCs) to strengthen their competitive advantages and expedite their export growth through the Mid-Tier Companies Development Programme (MTCDP). MTCDP is a nine-month customised programme to expand the Malaysian companies' reach into great potential business markets through visits and expert advice, to facilitate introductions to investors, local and international banking institutions, as well as to introduce the Malaysian firms to new technology and potential technology partners.

11.5.3 Innovative Capability

In general, firms with a higher level of innovative capability can change internally and effectively in response to new market changes. **Figure 11.13** show that E&E firms have invested more resources to enhance their innovative capability activities than average Malaysian firms. Across all areas, the Malaysian E&E firms have made higher investments in skills upgrading (59.2%), knowledge management systems (44.8%), design and engineering (39.2%), market intelligence (38.4%) and research and development (35.2%). These results indicate that the E&E firms are making great efforts in enhancing their innovative capability, which is critical for success in the face of fast-changing external technological developments.

Figure 11.13: Knowledge Intensive Activities in the E&E Industry

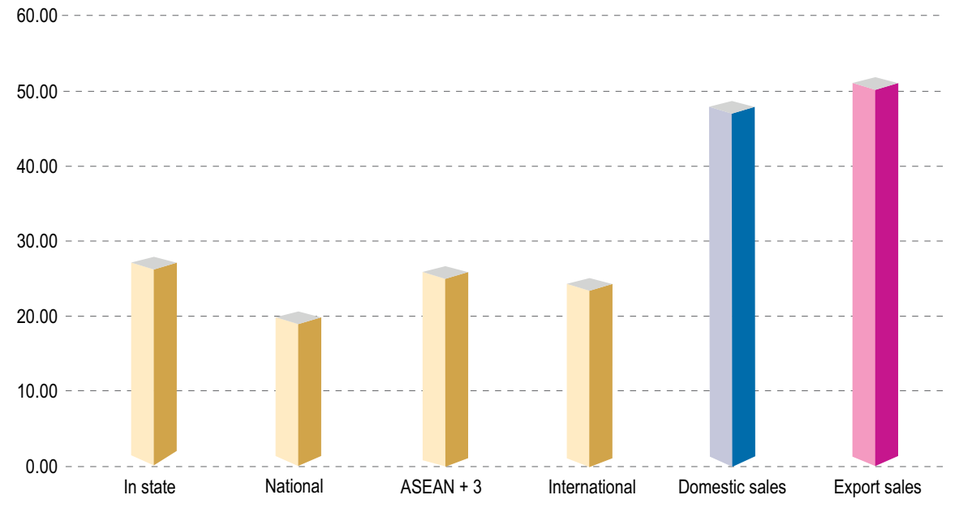


11.6 Outcomes of Dynamic Capabilities in the Electrical & Electronic Industry

The E&E industry has grown into Malaysia's largest contributor to exports, economic outcomes and employment. Its significance is shown in **Figure 11.14**, where export sales (51.71%) are higher than the domestic sales (48.29%). This can be attributed to its positive brand recognition in the international markets. Analysis from the qualitative data shows that the Malaysian E&E products have the hallmarks of product quality and competitive pricing. The export markets in 2014 include regional countries such as ASEAN plus China, Japan, and Korea (26.7%), and other nations at 25.02%.

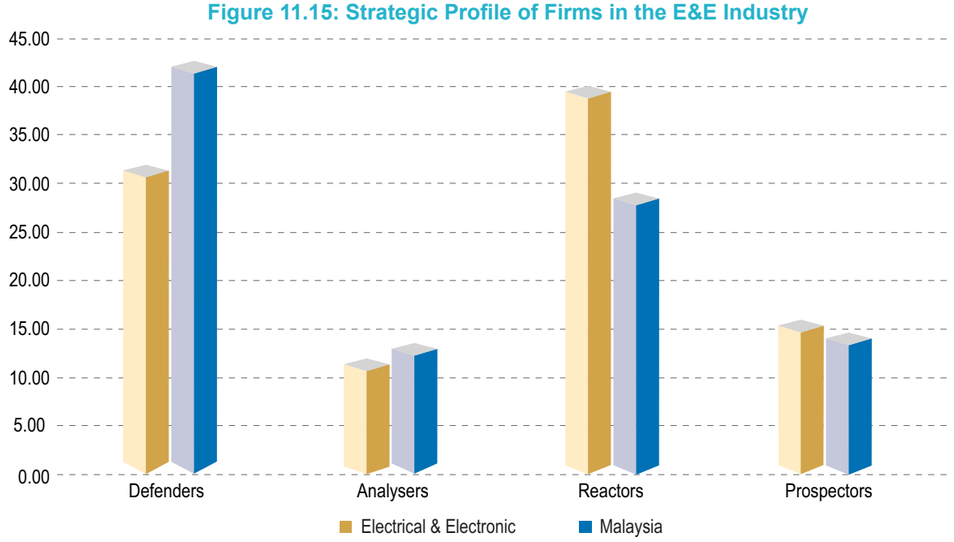
The strategic profile of the E&E industry shows the predominance of Reactors (40%) in the industry, surpassing the Malaysian average (see **Figure 11.15**). Defender companies make up the second

Figure 11.14: Market Presence of the Malaysian E&E Industry



Note: The results are based on survey data.

Figure 11.15: Strategic Profile of Firms in the E&E Industry



largest group with 32%, and below the national aggregate. The industry has a small group of Prospector firms (16%), which is slightly higher than the Malaysian aggregate. This is a positive sign as these E&E firms are risk-takers, capitalise on new market opportunities and focus on research and development. The smallest group of the industry is Analysers (12%), who comprise firms that are always 'second in' new markets or domains.

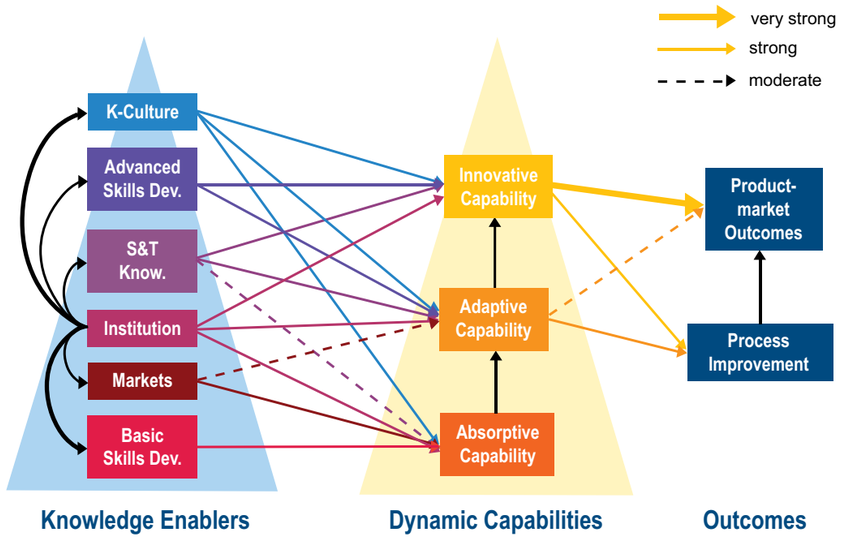
Taken together, the Defenders and Reactors firms form the two largest groups in the industry. This is one of the major weaknesses in E&E industry as Defenders and Reactors firms are often not able to adapt in a similar degree as other types of firms like Analysers and Prospectors, especially in the current volatile market.

11.7 Relationships between the Key Blueprints of the E&E Knowledge Ecosystem

In this section, we discuss the relationship between the knowledge enablers, dynamic capabilities and economic outcomes for the E&E industry. The Malaysian knowledge ecosystem for this industry is benchmarked with the industry from more advanced countries. Based on content analysis and the data obtained from DOS, this industry in advanced countries and in Malaysia is classified as a pace-setter, an industry with one of the highest knowledge content.

In **Figure 11.16**, the E&E knowledge ecosystem for advanced countries shows that the three components of the dynamic capability are supported very strongly by the knowledge enablers. In these advanced countries where E&E is a key industry, strong absorbability capability provides a good foundation for higher value-added innovative endeavours (adaptive capability). The sound ecosystem to support absorptive and adaptive capabilities enables the E&E industry to extend its innovative capacity and enhance its global reach, especially in developing new process improvements and generating new product outcomes.

Figure 11.16: Knowledge Ecosystem of the E&E Industry in an Advanced Country



Note: Very strong impacts are represented by the bolded line, strong impacts are represented by normal lines and moderate impacts are represented by dotted lines.

The E&E knowledge ecosystem for Malaysia is shown in **Figure 11.17**. This industry is classified as a pace-setter among the 21 industries in Malaysia. However, the knowledge ecosystem was found to be relatively weaker than that found in more advanced countries. The E&E knowledge ecosystem supports all three dynamic capability components and they primarily support process improvement. A summary of the strength of the E&E in advanced countries and in Malaysia are given in **Table 11.1**.

Figure 11.17: Knowledge Ecosystem of E&E Industry in Malaysia

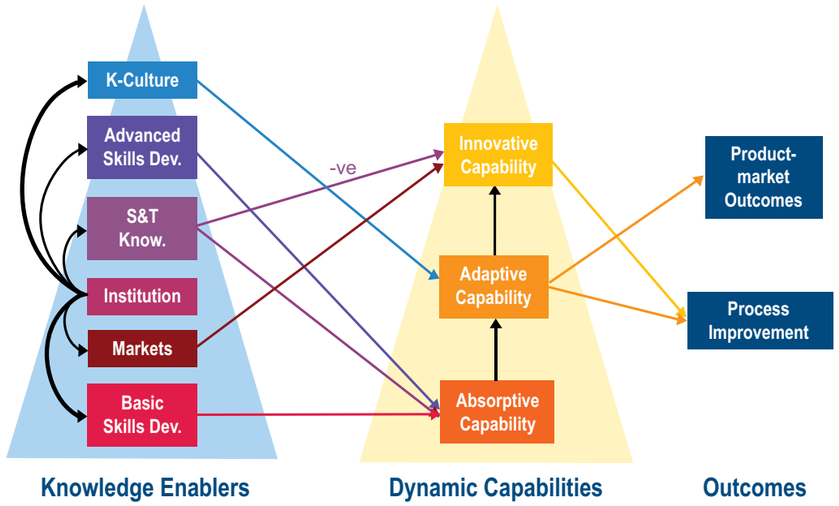


Table 11.1: Knowledge Enablers and Dynamic Capabilities for the E&E Industry

Advanced Countries	Malaysia
Basic Skills have a **positive and strong impact** on absorptive capability. In most developed countries, the technical and vocational education training (TVET) in schools, community and technical colleges (government and industry) and polytechnics are very strong and industry relevant. Regular trainings and workshop are conducted to ensure the workers are able to use sophisticated and rapidly changing technologies.	Basic Skills have a **positive and strong impact** on absorptive capability. The technical skills development is primarily undertaken by polytechnics, colleges, and universities. Medium and larger firms also have in-house program to up-skill their workforce. Most small firms find it hard to train workers due to lack of resources and cost of training is expensive.
Market Intelligence has a **positive and strong impact** on absorptive capability; and positive and moderate impact on adaptive capability. The industry has a strong network of suppliers, customers, competitors, external consultants and commercial R&D centres who play key roles in enhancing absorption and adaptation of new knowledge and technology. The IP regulations	Market Intelligence has a **positive and strong impact** on innovative capabilities. The Prospector and Analyser firms are the major drivers of innovation and knowledge creation; however, firms in these categories are small. A majority of local firms depend on suppliers, customers, foreign competitors, external

Table 11.1: Knowledge Enablers and Dynamic Capabilities for the E&E Industry (cont'd)

Advanced Countries	Malaysia
are transparent, clear and well enforced – hence, firms are able to share knowledge without being concerned about infringements of IP rules or non-disclosure agreements. The efficient regulatory system enhances the speed of information dissemination and sharing among all stakeholders.	consultants, commercial R&D centres, technology partners (OEM partners) for knowledge, R&D and innovations. Local firms tend to license foreign technology and undertake minor modifications to suit their market conditions. Most of the innovations are incremental innovation and to achieve better cost advantage.
Institutions are **strong enablers** of the knowledge ecosystem and have **direct strong and positive impact** on all three dynamic capability components. Government research institutions (GRI), universities, regulators and trade associations play a key role in shaping the E&E ecosystem and influencing the dynamic capabilities components directly. For example, universities, industry and government research institutes are undertaking path-breaking R&D that will contribute to the development of the industry. Various incentives are provided by government in the form of R&D and other grants to undertake leading research and capabilities development of the industry. Industry and trade association provide linkages within the industry. They are also a strong lobby group for pressuring governments to make changes in the regulations and getting resources for their stakeholders. Among the resources is the establishment of prototypes and testing centre, where all the industries can experiment and test new products. There is shared vision and strong partnerships between all players to enhance the competitiveness of the E&E cluster in these advanced countries. Key priorities are identified and supports to develop these areas are channelled to the appropriate stakeholders. Among the programs introduced to support the development of the industry are SBIR and Manufacturing Extension Programs.	Institutions **strong enablers** for all the other knowledge enablers, but **does not impact** the three dynamic capability components directly. Key institutions such as regulators, trade associations, universities and government agencies play key roles in ensuring the E&E ecosystem is developed. Strong government support to attract leading MNCs to use Malaysia as their hub for R&D and manufacturing. However, the roles of these institutions in directly impacting the dynamic capability components were found not to be significant. Most of the major players are foreign MNCs with their own technology and capabilities. Most Malaysian firms are OEM or suppliers for the MNCs. The take up rate of research by local universities and GRIs is miniscule. Even the training provided by Malaysian educational institutions were found to be not industry relevant. As such, industries have to spend resources to up skill the graduates. The partnership between all the institutions is patchy and not coordinated. Hence, strategic directions and development of the industry is uncoordinated, lack focus have not moved up the global innovation value chain.

Table 11.1: Knowledge Enablers and Dynamic Capabilities for the E&E Industry (cont'd)

Advanced Countries	Malaysia
Science and technology knowledge has a **positive and moderate impact** on absorptive capability; but, positive and strong impact on adaptive and innovative capability. In most advanced countries, basic and applied R&D activities in the E&E related areas are very strong and focussed on key strategic areas that will power the next generation products and services in diverse industries. Significant resources are also invested to ensure that there are strong partnerships between all stakeholders in the E&E ecosystem. Strong collaborations between SMEs and large organisations with universities and research institute results in spill-over benefits in the form of SMEs having access to new technology and knowledge that help them build absorptive and adaptive capabilities. Larger firms tend to invest significant resources within research universities or develop their own research laboratories and encourage strong research linkages to leading research universities and centres. Some universities work closely with industry to spawn new spin-off companies that are built around a technology or intellectual property that have commercial value. The SBIR and Manufacturing Extension programmes in USA are excellent models where S&T is diffused to industries, especially SMEs to build the dynamic capabilities. Leading researchers and industry attend conferences and other forums to acquire knowledge and this is then transferred to other key personnel.	Science and technology knowledge has a **positive and strong impact** on to absorptive capability. On the other hand, Science and technology has a **negative and strong impact** on innovative capability. The latter results show that **S&T knowledge imposes an opportunity cost** on the innovative capability of the industry. The R&D in the local E&E related areas are not at the frontier – local R&D tends to lag behind more developed countries. Lack of talented staff in key research priority areas and weak industry-university partnership has led to a majority of the firms in the industry being dependent on foreign technology and know-how to create value for their operations. Most of the high quality Malaysian R&D personnel are either working in leading research centres or MNCs in more advanced countries. Most of the engineers and technical staff trained in local institutions lack the R&D skills training to operate in high-intensive environment due to lack of opportunities to work and study in such environments. A majority of the university graduates at best good to use technology developed in more advanced countries or MNCs. This suggests that most of the S&T knowledge is to improve the absorptive capacity of a majority of the industry players in Malaysia. Lack of high-end research personnel in Malaysia and low commercial value for local research may result in high opportunity cost of investing in high R&D for local firms. MNCs, including local firms prefer investing in R&D in countries such as Singapore, India and US, where there are adequate supply of talented engineers and scientists, cutting-edge facilities and strong industry-university linkages.

Table 11.1: Knowledge Enablers and Dynamic Capabilities for the E&E Industry (cont'd)

Advanced Countries	Malaysia
Advanced Skills have **a positive and strong impact** on both innovative capability and adaptive capability. In many of advanced countries, significant resources are invested to strengthen the STEM, computer science, data analytics and ICT areas. These countries invest in research programs, PhD courses and develop incentive schemes to attract the best talent to the countries to develop the industry. Strong partnerships between industry and universities also help these countries close the 'knowledge-commercialisation chasm' – firms are able to enhance their adaptive and innovative capability. There are also concerted efforts to educate firms on new entrepreneurial models, marketing and promotion methods, branding, financial tools and management, improving quality of services and improving the positioning of the firms in the broader industry. The Trade Associations and government agencies and universities in many of the advanced countries play important roles in assisting SMEs to acquire this advanced knowledge to improve their knowledge content and competitiveness.	Advanced Skills have **a positive and significant impact** on absorptive capabilities only. There has been increase in skilled workforce in the E&E from the 1980s. However, the diffusion of knowledge and innovation in the industry has increased due to inflow of foreign firms. The local industry is still dependent in foreign knowledge and expertise. A majority of the talented workforce are users of new technology and innovations from foreign firms with advanced R&D capabilities. Further, talent with highly specialised skills tend to work for foreign MNCs or migrate to more advanced countries where the opportunities to undertake cutting-edge R&D and career prospects are much better. The 'brain-drain' problem hinders the industry for translating the advanced skills development in building adaptive and innovative capabilities of the industry. Malaysian firms are good OEM players, but are weak in developing a brand or position themselves in the global market. Many of the firms invest resources to develop advanced skills that will enhance their reach and richness of their products and services.
Knowledge culture has a p**ositive and strong impact** on all three dynamic capabilities. The pace-setter firms invest in recruiting and retaining the best talent from across the globe. Most of the organisations are rather flat in terms of management and innovation is everyone's responsibility. Diversity in skills and expertise are valued and many of firms undertake multidisciplinary R&D endeavours. These firms also constantly run trend regression and undertake competitor analysis to ensure they remain at the he frontier of innovation and new development. These firms invest significant resources in upgrading the skills of the workforce and put	Knowledge culture has a **positive and strong impact** on adaptive capability. The Prospector and Analyser firms invest in attracting talent and advanced skills development to enable its workforce to undertake leading-edge R&D and innovations. A majority of the firms invest in adapting existing innovations to meet the needs of local market demand. Most local firms are dependent on foreign knowledge and expertise. Hence, many do not invest in hiring the best talent to undertake home-grown R&D and innovations. The talent hired are to learn foreign technology or innovation; and at best modify them to meet local market demand.

Table 11.1: Knowledge Enablers and Dynamic Capabilities for the E&E Industry (cont'd)

Advanced Countries	Malaysia
in place mechanism for sharing best practices. Employees are given the best environment to undertake experimentation and simulations to push the frontier of knowledge and innovation. Employees are encouraged to take risks and in some firms, failures that lead to ground-breaking discoveries are also rewarded, Some of the big players work closely with universities and research centres to undertake leading-edge R&D. The commercialisation of the R&D activities is undertaken by the firm and in some cases these firms spawn new start-up companies with universities and research institutes.	Most SMEs tend to be 'top-down' and 'risk-averse'. Very few of the firms invest in R&D activities and many are reluctant to share best practices or ideas across the industry due to highly competitive nature of the industry. Due to high staff turn-over, many firms do not invest in advanced training and share innovations with employees. Due to the work environment and culture in local firms, many of the local talented staff prefers working for foreign MNCs and research centres where opportunities to develop their career are much better.
The continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** These countries invest significant resource in technical training and STEM related education from primary to post-doctoral training. There is a strong research-led education philosophy incorporated at all levels of the education and training. This is strengthened by strong partnership between the learning institutions and industry. The E&E clusters in many of the developed countries work closely with other industrial clusters. Further, there is strong support from government (Taiwan, Korea and Japan) in these countries to support local industries firm – "buy local products first" is practiced in most of these countries. Sound STEM education at all levels, coupled with strong support from government and local market for the local products have enabled the E&E industries to have very strong absorptive, adaptive and innovative capability; enabling the industry to have a strong foundation in the local market – a sound platform to expand their global reach.	The continuum from absorptive capability to adaptive capability to innovative capability **is present.** Since the 1980s increased investment in STEM related areas and increasing large foreign MNCs have increased the absorptive and adaptive capability of the Malaysian E&E workforce. Many of the local firms have also been beneficiaries of knowledge and technology transfer by being part of the supplier network for the MNCs. Over time some of the local players are not only major supplier for the leading MNCs, but some of them are producing final products for the domestic and regional market. The local cluster network is strong due to several anchor foreign MNCs who choose Malaysia as their test best for new innovations and manufacturing. Lack of large globally competitive Malaysian MNCs in this space and mobility of the foreign MNCs poses a major risk for the sustainability of the local E&E industry.

In **Table 11.2** the impact of dynamic capabilities on economic outcomes for the E&E industries for both advanced countries and Malaysia are summarised. In sample advanced countries, adaptive capability for the E&E were found to have a positive and strong impact on process improvements; and, positive and moderate impact on product market outcomes. On the other hand, innovative capability was found to have a positive and strong impact on process improvement and a very strong to product market outcomes. This suggests that this E&E industry very strong in producing process improvement and generating new market outcomes.

On the other hand, the adaptive capability was found to have a strong and positive impact on both process improvement and product market development for the E&E industry in Malaysia. The innovative capability was found to contribute to process improvements only. Most of the innovations undertake by local firms to ensure the products and services are globally competitive by adopting new improved processes, improved internal management and organisational methods and improved marketing approaches. These improvements ensure the products and services are cost competitive, especially if local firms are dependent on foreign technology and are suppliers for foreign MNCs.

Table 11.2: Dynamic Capabilities and Economic Outcomes for the E&E Industry

Advanced Countries	Malaysia
Adaptive capability has a **positive and strong impact** on process improvement and a **positive and moderate impact** on product market development. There are firms in the E&E industry; especially SMEs are very strong in adapting new technology and innovations to improve existing products line. Many of the firms are new start-up firms that emerge from universities and research institute that are able to create new E&E applications for a broad range of industries.	Adaptive capability has a **positive and strong impact** on process improvement and a **positive and strong impact** on product market development. The local firms build their capability by leveraging on knowledge technology developed in more advanced countries. Much of the focus is on enhancing process improvements. There are firms in the industry that are able to produce niche products primarily adapting existing technology for the local and regional markets.
Innovative capability has a **positive and strong impact** on process improvement and a positive and very strong impact on product market outcomes. Many of the firms invest in major industrial R&D initiatives and work closely with leading centre of excellence across the globe. Being part of the strong global innovation network enables firms to access the global talent pool, resource and markets. The consumers are also included as part of the 'global innovation network', accessing information on improving existing products and developing new products to meet current market trends and demand.	Innovative capability has a **strong impact** on process improvement only. Innovative **does not impact** product market outcomes. Most local firms adopt new technology and innovations from MNCs. They primarily focus on improving cost-efficiency, service quality and meeting domestic market demand.

Table 11.2: Dynamic Capabilities and Economic Outcomes for the E&E Industry (cont'd)

Advanced Countries	Malaysia
Process improvement positive and **moderate impact** on product market outcomes. Globally competitive E&E clusters are due to very strong S&T base in many of these countries, which have enabled multidisciplinary translational research and new applications within the E&E industry and across other industries. These have not only increased the role of the E&E industry as key revenue earner, but also an important enabler for improving productivity in other industries and the overall economy.	Process improvement **does not impact** product market outcomes. A majority of the process improvements undertaken by firms in the industry are based on foreign technology and intellectual property. Further, the R&D landscape in Malaysia is rather uncoordinated and lack sharing of best practices and collaborations. Hence, the potential of creating new products and services for diverse industries are limited.

11.8 Summary: Key Trends, Challenges, Way Forward and Best Practices

11.8.1 Industry Trends

Over the years, the E&E industry has been Malaysia's industrial bread and butter. Besides attracting leading global E&E firms to operate in Malaysia, the industry has grown several successful Malaysian E&E firms, competing in the international market.

This MYKE III survey shows that E&E firms are contributing significantly to the growth of Malaysia's knowledge economy. Specifically, there has been an expansion of knowledge-intensive activities and investments in this industry to build its dynamic capabilities. This is reflected by **Figure 11.9** where the E&E industry performs better than the Malaysian industry aggregate in several key areas including absorptive capability, adaptive capability, innovative capability, process improvement and product-market development or innovation.

E&E is among the most technology-driven and knowledge-intensive of the 21 industries present in Malaysia. However, the E&E markets are extremely competitive and to remain at the top of the value chain, firms need to be agile and adaptive and develop an E&E ecosystem to enable firms to continuously improve and innovate.

11.8.2 Challenges

E&E industry is a key revenue generator for the manufacturing sector. In recent years, there has been a shift in E&E manufacturing activities to higher value-added E&E products due to major scientific and technological breakthroughs in the industry. While Malaysia is a major E&E hub in the region, the industry faces intense competition from other regional players; and the industry is experiencing a number of challenges. Below are the key challenges encountered by firms in the Malaysian E&E industry.

Institutions:

- The industry has developed in an ad-hoc way – sub industries are fragmented.
- Lack of long-term plan with clear tractable KPIs, milestones, regular audits and refinements.
- Highly competitive industry. Cooperation between all stakeholders is patchy and weak.

Basic Skills Development:

- Quantum and quality of TEVT educated workers for the industry are scarce.
- TEVT education lags behind the needs of a fast-changing industry.
- The industry is over-reliant on foreign workers.

- SMEs have a major challenge recruiting technically competent staff.

Advanced Skills Development:

- Only large firms have staff with advanced knowledge and skills to reconfigure and apply knowledge at a higher level of creativity.

- Skills of graduate do not meet the needs of creative work in the industry. Most S&T graduates are good users of knowledge and not creators of new innovations.

- SMEs have major challenges recruiting high calibre workers with most qualified local k-workers preferring to work overseas or with MNCs.

S&T Knowledge:

- Shortage of technical staff and high demand for talent in the regional and global industry cause the local industry to lose valuable highly sought after professionals to competing countries.

- Insufficiency of advance skills and knowledge to locally create advancements on the S&T frontier.

- Lack of quantum and quality in S&T investment in frontier E&E technologies infrastructure and R&D.

- SMEs lack financial resources for undertaking frontier R&D and technological development. There is limited access to state of the art facilities and expertise.

Market Intelligence:

- Networking among the key stakeholders is not strong and sharing of information is scarce in this highly competitive industry.

- Low use of ICT among SMEs with many failing to access information that is strategic to the development of the firm and local industry.

- Lack of trust is a major hindrance due to failure to follow formal business rules. For instance, NDA's and IPs are easily and often contravened.

- Local players have limited feedback on end-products because they do not have extensive market presence and visibility: Taiwanese (e.g. Asus) and Korean (e.g., Samsung) products attract significant feedback on product improvement from sophisticated consumers.

- Local firms do not have strong market presence domestically or internationally in the end-products market.

Knowledge Culture:

- Local firms are highly dependent on foreign firms for technology. This is the case especially for SMEs. A strong 'lock-in effect' prevails.

- Firms (especially SMEs) are risk averse and willing to 'cash-out' their IPs/innovations to bigger players or foreign MNCs.

- Nurturing start-up firms in local research institutions is not common practice. The university ecosystem is not sufficiently developed to spawn start-ups around R&D and product innovations.

11.8.3 Way Forward

The E&E industry is the backbone of the national industrial development. To ensure the E&E industry moves up the innovation value chain and sustains its contribution to national wealth, Malaysia needs a more holistic approach in developing the E&E ecosystem. This includes ensuring that the blueprints of the E&E knowledge ecosystem are able to strengthen the dynamic capability of local E&E firms and translate the capability into economic opportunities and outcomes. Major transformations should take place to enable firms to improve knowledge intensity. Key recommendations to strengthen the E&E knowledge ecosystem are discussed below.

Recommendation 11.1: Focus Development in Key Priority Areas with Global Potential

- Institutions (trade associations, government agencies and universities/learning institutes) should work together to focus efforts in key priority areas that will be the 'building-blocks' of future industries and socioeconomic development:
  - Next-generation semi-conductors; Solar & green technology; Light Emitting Diodes (LED) and Organic Light Emitting Diodes (OLED); Integrated electronic design; printed electronics; Passive components; Internet of Things (IoT); Consumer electronics.

- Build global partnership in the above-mentioned technologies with leading innovation hubs. Local industry should be an integral part of the global innovation network for frontier innovations.

Recommendation 11.2: Nurturing E&E Savvy Creative Talent and Workforce

- Intensify TEVT training with E&E as a major in high school (SPVM), technical colleges and polytechnics by working closely with major industry players.

- Ensure cost-effective continuous training programs (leading to certification) are available via colleges and polytechnics.

- Foster strong university-industry collaboration in curriculum design, course development, internships and work placements.

- Develop large scale university-industry research programs and doctoral courses in the above mentioned areas and applications.

- Establish transnational research centres that work with leading global centres of excellence to develop indigenous technology and innovations. Training local people to become global leaders and thinkers in the field.

Recommendation 11.3: Enhancing the E&E Business Ecosystem

- Establish a cost-effective E&E and Wireless Testing Platform & Industrial Design Centre of Excellence.

- SIRIM certification and patenting process should be simplified and made cost-effective for SMEs and start-ups.

- Establish a One-stop centre for SMEs to source information on a wide range of services, incentives, resources, regulations, networks and internationalisation strategy that will enhance their competitiveness.

- Government and GLCs should be key users and promoters of local technology and innovations.

Recommendation 11.4: Strengthening 'Quadruple-helix' in E&E Clusters

- Establish a high-level panel consisting of key stakeholders to develop a strategic master plan for the E&E industry with clear KPIs, resources and outcomes to raise innovative capacity and competitiveness in priority areas.

- Foster strong strategic partnership between SMEs and universities via programs, such as the E&E extension programs and Small Business Innovation Research (SBIR) programs modelled after the programs in the US, whereby public universities and technical colleges across the country become key anchors for assisting scale-up and development of the E&E industries in different localities.

11.8.4 Best Practices

The E&E ecosystem has been a strong foundation for Malaysia's industrial development. Converging technology platforms over the last decade have resulted in increasing competition in the E&E industry. In this section, best practices from pace-setter countries are discussed.

Best Practice 11.1: Focus Development in Key Priority Areas with Global Potential

European Union – Korea Joint Science and Technology Cooperation

This joint collaboration has significant spill-over benefits in focusing development in key strategic areas that will lead global development in the E&E and other competing industries. Among the key objectives of the collaboration are to achieve the following:

- Deepen and scale research collaboration in key thematic areas: nano-electronics, 5G-next generation communication networks, IoT, cloud services, CO2 capture technologies, nano-safety, materials modelling, innovative medicine, medical devices, energy efficient technology and satellite navigation.
- Encourage researcher mobility, which will foster knowledge and technology transfer between researchers in Europe and Korea.
- Foster 'top-down' (government-to-government) funding, 'bottom-up' (researcher and innovator collaborations) and 'demand-driven' (public-private partnership) cooperation to develop the thematic research areas.
- Develop bilateral cooperation to support R&D based start-ups that will undertake "blue-ocean" innovations, enhancing competitiveness of the E&E industries in Korea and EU.

Best Practice 11.2: Nurturing E&E Savvy Creative Talent and Workforce

TEVT Education in Finland

- Clear pathway to higher education is articulated from certificate to doctoral program in technical universities.
- Curriculum designed collective with key industry players, trade associations and universities (institutions) aligned with national strategic priority industries.
- Job training, internship, apprenticeship and mentorship are key components of all TEVT education. This ensures graduates are job-ready.
- Competitive remuneration, continuous improvement of the teaching & learning environment; access to high quality professional development programs for TEVT educators.
- Publicity campaigns jointly with industry to highlight the benefits of TEVT education in the local media, digital platforms and meetings. This effect can be enhanced by showcasing the achievements of students.

Best Practice 11.3: Enhancing the E&E Business Ecosystem

Taiwan E&E and Wireless Testing Platform

- Provides efficient, cost-effective and comprehensive testing on a wide range of E&E and communication products and services.
- Has a network of global offices that provide in-depth knowledge and testing requirements across the globe.
- Assists with testing products and certification of products in Taiwan and the relevant international markets.

Best Practice 11.4: Strengthening 'Quadruple –Helix' in the E&E Clusters

Small Business Innovation Research (SBIR) Program – Small Business Technology Transfer (STTR) Program in the USA

- Foster strong strategic partnership between SMEs, universities and government agencies to support technological innovation to stimulate technological innovations; foster technology transfer via collaboration between small businesses and research institutions; and increase commercialisation of government funded R&D in key national strategic priority areas, such as frontier technologies for the E&E industry.
- Encourage the socially and economically disadvantaged to participate in innovative endeavours and enhance their entrepreneurial acumen.

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CHAPTER 12

KNOWLEDGE CONTENT OF THE MACHINERY AND INSTRUMENTS INDUSTRY

CHAPTER 12
Knowledge Content of the Machinery and Instruments Industry

12.0 Introduction

The industrial revolution is in its fourth generation, known as "The Fourth Industrial Revolution," with increasing convergence between digital platforms and industrial value chains (German Electrical and Electronic Manufacturers Association [ZVEI], 2015). In order to remain globally competitive, it is necessary for Malaysian machinery and instrument (M&I) firms to embark on transformative roadmaps that allow them to reassess, calibrate and improve upon existing technological resources. The M&I industry is classified into four types (Ministry of International Trade and Industry [MITI], 2015): (1) power generating machinery and equipment; (2) metalworking machinery; (3) special-purpose machinery or equipment for specific industry; and (4) general-purpose machinery or equipment, components and parts. The manufacture of special-purpose machinery group caters for manufacturing industries (e.g., food, textile and biotechnology) and non-manufacturing industries (e.g., aircraft launching gear and amusement park equipment). On the other hand, the creation of general-purpose machinery group supplies components and machinery to a range of MSIC industries (e.g., cranes, cold-room equipment, welding machines and air-conditioning plants).

12.1 Key Developments and Initiatives

In a concerted effort to grow the M&I ecosystems in Malaysia, the government has implemented three Industrial Master Plans to develop the manufacturing industry. The First Industrial Master Plan (IMP1) (1986-1995) articulated the goal to have the manufacturing industry be the primary growth and exports driver of the nation. The Second Industrial Master Plan (IMP2) (1996-2005) pushed for the development of the manufacturing industry with increased value-added activities, stronger industrial linkages and higher productivity. Malaysia's efforts to attract major M&I manufacturers have paid off, with global companies such as Technip, OneSubsea, Carrier International, Emerson, Bromma, SKF, Aker Solutions and etc. operating locally. The Third Industrial Master Plan (IMP3) (2006-2020) focuses on enhancing global competitiveness through a number of transformation plans in both the manufacturing and services industries. In IMP3, M&I is one of the 12 industries in the manufacturing industry identified for further development. High-growth M&I products include metalworking machine tools, materials handling equipment, specialised machinery, packaging machinery and fuel cell power generators (Ministry of International Trade and Industry [MITI], 2015). According to Ministry of International Trade and Industry [MITI] (2014), the targeted total exports for M&I industry in the period of 2006 to 2020 is RM494.4 billion, with an average annual growth rate of 6.4%.

In 2013, exports of general industrial M&I, components and parts maintained their position as the largest export category of the M&I industry, with a value of RM14.2 billion. The exports are mainly marketed to Australia, Hong Kong, Japan, Singapore and USA. Among leading products and companies in this sub-industry are (1) Elevators (e.g., MS Elevators, Kone Elevator, UWC Technology and Eita Pacific); (2) Conveyor/Factory Automation (e.g., Cheng Hua Engineering, AT Engineering Solution, General System Engineering, FlexMove System and AFA Technologies); (3) Air-conditioning plants (e.g., Dunham-Bush, OYL Industries, TM Air Conditioning, Carrier International and Citec International); (4) Pressure vessels/process equipment (e.g., KNM Process Systems, Amalgamated Metal, Aker Process Systems and Mechmar); (5) Cooling tower (e.g., BAC Cooling Technology, Linear Cooling Industries, Panwater Engineering); (6) Cranes: (e.g., Favelle Favco, Impsa Malaysia, MHE Demag and Top Mech Provincial). At present, Malaysia is the third largest tower crane manufacturer in Asia, after Japan and China. Most notably, Favelle Favco is one of the prominent manufacturers for high-speed heavy lifting tower cranes and pedestal cranes for oil and gas.

The share of exports of M&I for specific industries registered at RM9.8 billion, making them the second largest M&I export category in 2013. The main exports destinations consist of Indonesia, Singapore, Thailand, Japan and USA. The key products and companies in this sub-category include (1) Oil and gas M&I - Exploration and production (e.g., FMC, Aker Solutions, OneSubsea, Halliburton, Asiaflex, Baker Hughes and Schlumberger) and Engineering and fabrication (e.g., Sime Engineering, KNM Group, SapuraKencana and MMHE); (2) Electrical and electronics M&I – Semiconductor (e.g., SRM, Kobay Technology, ViTrox, Ismeca, Upeca Equipment and Pentamaster), solar (e.g., Stoppani and Greatech Integration), hard disc drive (e.g., Genetec), LED (e.g., AGS Automation and Dominant Opto Technologies); (3) Packaging M&I (e.g., Fluidmech Engineering, Serac Asia and Master Hi-Tech); (4) Agricultural M&I – Cultivation (e.g., Emdek Engineering, Howard Alatpertanian, Changlin Machinery, Sime Darby TMA), Poultry (e.g., BD Agriculture, Eurasia, Nabel Asia and GSI Asia); (5) Plastic extrusion machine (e.g., Micromagna Engineering, Sunrich Engineering and Sama Plastic).

Malaysia is known as the largest manufacturing hub for boilers in the Southeast Asia region. However, exports of power generating M&I declined from RM2.2 billion in 2012 to RM2 billion in 2013. The top export countries include Japan, Germany, Singapore, UK and USA. Major products and manufacturers in this sub-industry include (1) Boilers (e.g., Mechmar Boilers, Vickers Hoskins, Advance Boilers, Amalgamated Metal Corp, Enco Systems, Petra Boilers, Tenaga Tiub and Transtherm Engineers); (2) Generators (e.g., Sime Darby Industrial, UMW Industrial Power, Hong Seng Generator and MTU Services); (3) Turbines and components (e.g., Turboservices Overhaul, Noorisba Energy, Serba Dinamik Turbo Machinery and Galaxy Energy Technologies)

The metalworking M&I contributed RM1.3 billion to total exports in 2013. Although this sub-industry constituted the lowest share of total export, local manufacturers have the capabilities to produce various machines such as machining centres, electro-discharge machines (EDM), laser-cutting machines, drilling machines, milling machines, shearing machines, forging machines, lathes, stamping machines, bending rolls, press brakes, and presses. The machines are mainly exported to Hong Kong, Japan, Singapore and USA.

Malaysia also imports substantial M&I products from import partners such as Japan, Germany, USA, Taiwan, Singapore, Thailand and China. The import of M&I was valued at RM54.5 billion in 2013.

Table 12.1: Exports

M&I sub-industries	2008	2009	2010	2011	2012	2013	Major countries
	RM billion						
Power generating M&I	2.7	2.2	2.4	2.4	2.2	2.0	Japan, Germany, Singapore, UK, USA.
M&I for specific industries	5.7	5.8	6.9	7.7	8.6	9.8	Indonesia, Japan, Singapore, Thailand, USA.
Metalworking M&I	1.4	0.9	1.2	1.4	1.2	1.3	Hong Kong, Japan, Singapore, USA.
General industrial M&I, components and parts	12.1	10.2	10.9	12.2	13.2	14.2	Australia, Hong Kong, Japan, Singapore, USA.
Total	**21.9**	**19.1**	**21.4**	**23.7**	**25.2**	**27.3**	

Source: Malaysian Investment Development Authority [MIDA] (2014)

Table 12.2: Imports

M&I sub-industries	2008	2009	2010	2011	2012	2013	Major countries
	RM billion						
Power generating M&I	10.3	9.3	8.7	9.2	10.7	10.9	USA, Japan, Singapore, China, Thailand.
M&I for specific industries	12.3	10.4	13.7	15.6	15.5	16.3	Japan, Germany, USA, Taiwan, Singapore.
Metalworking M&I	4.0	3.0	4.5	4.1	4.8	4.2	Japan, Germany, USA, Taiwan, Singapore.
General industrial M&I, components and parts	16.7	15.4	17.0	18.1	21.9	23.1	Japan, Germany, USA, Taiwan, Singapore.
Total	**43.3**	**38.1**	**43.9**	**47.0**	**52.9**	**54.5**	

Source: Malaysian Investment Development Authority [MIDA] (2014)

The major association that represents firms in this industry is the Machinery and Equipment Manufacturers Association of Malaysia (MEMA) (formerly known as Heavy Equipment and Machinery Manufacturers Association of Malaysia, HEMMAM). MEMA was founded in 1998 during the Second Industrial Mater Plan (IMP2, 1996-2005) and is a key enabler for the growth of machinery and instruments industry in Malaysia. It plays a strong role in promoting cooperation among small and medium scale manufacturers of machinery and equipment in Malaysia through information sharing, training and education, research and development and technology upgrading among its members.

Other agencies and institutions involved in the development of machinery and instruments industry include the Association of Consulting Engineers Malaysia (ACEM), Engineering Accreditation Council (EAC), Board of Engineers Malaysia (BEM), Institution of Engineers Malaysia (IEM), Institution of Surveyors Malaysia (ISM), Malaysian Institute of Planners (MIP), Professional Services Development Corporation (PSDC), Malaysian Industrial Development Authority (MIDA) and Ministry of International Trade and Industry (MITI).

The Malaysian Government also introduced a number of laws to ensure the sustained development of this industry. The Malaysian legislations for M&I industry include the Industrial Coordination Act 1975 (ICA), Promotion of Investments Act 1986 (PIA), Electricity Supply Act 1990, Electricity Regulations 1994 and so on. Over the years, the government has revised its labour policies including the Employment Act, 1955, Trade Unions Act, 1995, and the Industrial Relations Act, 1967, to meet the current requirements of the labour market. These legislations have helped to support the development of the machinery industry through simplifying the process of dismissal and enhancing employee welfare.

To encourage the development of the industry, the government also provided various tax incentives. The targeted areas of M&I that receive tax incentives include machine tools, material handling equipment, robotics and factory automation equipment, packaging machinery, specialised process machinery or equipment for specific industry, modules and components of the above-mentioned. Currently, the Malaysian corporate tax rate is 25% and new incentives offered for M&I industry are listed in **Table 12.3.**

Table 12.3: Malaysian Corporate Tax Incentives

No	Tax incentives
1	Pioneer Status with tax exemption of 70% to 100% of statutory income for a period of 5 to 10 years.
2	Investment Tax Allowance of 60% to 100% on qualifying capital expenditure incurred within a period of 5 years. This allowance can be offset against 70% to 100% of the statutory income for each year of assessment.
3	Reinvestment Allowance of 60% on qualifying capital expenditure for 15 years.
4	Import duty exemption for machinery and equipment; spare parts and consumables; and raw materials and components.

Source: Malaysian Investment Development Authority [MIDA] (2014)

The replacement of the Sales and Service Tax with 6% GST has had an impact on the M&I industry. GST came into effect on 1st April 2015. However, all exports are zero-rated where export-oriented manufacturers do not collect output tax on their supplies.

One of the major challenges encountered by this industry is access to qualified workers. As of 2013, 17% of total employment in Malaysia consists of registered foreign workers (Economic Planning Unit, 2015). Citing manpower concerns, the Malaysian Government introduced the 6P program in 2011, allowing illegal foreign workers in the manufacturing industry to register with the Home Ministry and secure a three-year work permit. The term '6P' stands for Pendaftaran (registration), Pemutihan (legalisation), Pengampunan (amnesty), Pemantauan (supervision), Penguatkuasaan (enforcement) and Pengusiran (deportation). This program has assisted in mitigating the economic consequences of losing workers in the machinery industry.

In April 2015, the Technologists and Technicians Bill 2014 was passed to set up the Malaysia Board of Technologists (MBOT). The aim of MBOT is to help 30,000 technicians and technologists to be recognised as professionals by providing educational and vocational training, as well as registering and recognising the professions.[4] This initiative will enable the technologists to become more sought-after within the industry, and thus able to contend for higher salaries complementing this, four universities (Universiti Tun Hussein Onn Malaysia (UTHM), Universiti Teknikal Malaysia Melaka (UTeM), University Malaysia Pahang (UMP) and Universiti Malaysia Perlis (UniMAP)) established the Malaysia Technical University Network (MTUN), an alliance to produce professional technologist by training the post-secondary and college Technical and Vocational Education and Training (TVET).

[4] According to MOSTI, a technologist is defined as a TVET graduate and/or practitioner with a minimum degree in engineering technology and/or a technician with a minimum diploma qualification.

12.2 Knowledge Content

Figure 12.1 shows a mixed trend in the knowledge resource foundations of M&I industry over the period 2003 to 2014. There is a small increase in technology and infostructure in 2014. Empirical analysis shows no change for most of the dimensions, namely, leadership, knowledge environment and knowledge generation. Assessment of M&I's performance in knowledge enablers and actions shows a decline in human capabilities, knowledge utilisation and knowledge sharing between 2007 and 2014.

12.3 Knowledge Enablers

12.3.1 Human Capabilities

Human capabilities in the M&I industry remain higher than the Malaysian aggregate index over MYKE I, II and III (see **Figure 12.2**). This is because jobs in the M&I industry generally require a fair degree of technical competence. However, the M&I industry has slipped to 0.57 (2014) from 0.76 (2007) in its human capabilities index. At the firm level, results show that human capability for all M&I firms, irrespective of local

Figure 12.1 Overview of Knowledge Enablers and Knowledge Actions for MYKE I, MYKE II and MYKE III

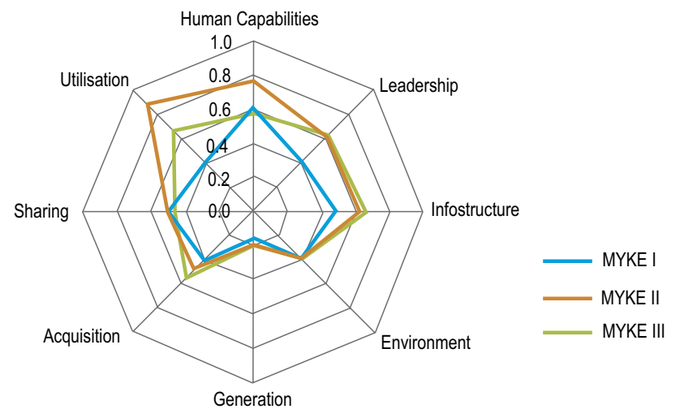
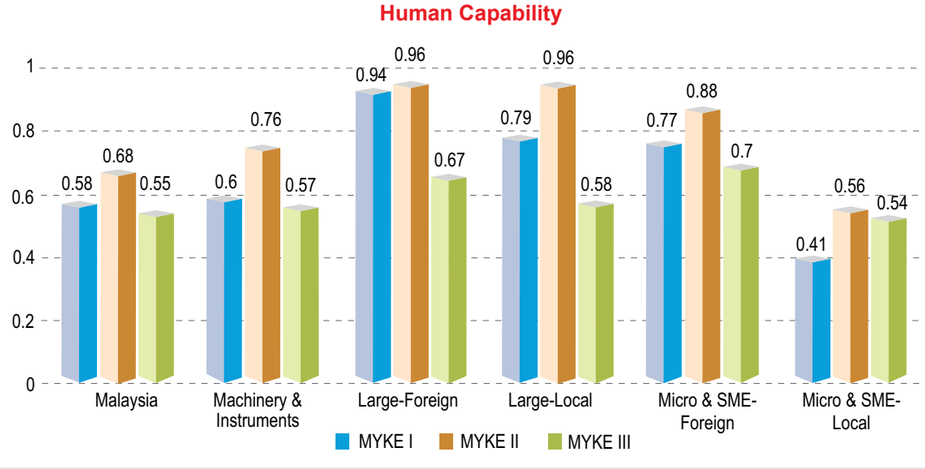


Figure 12.2: Human Capability of the M&I Industry



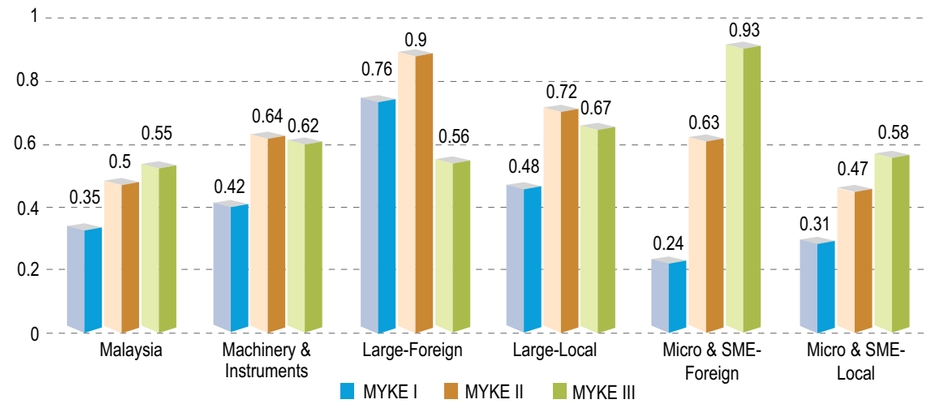
or foreign, large or small, have reported a decline in its ability to attract talent and provide staff training. Large foreign firms dropped from 0.96 (2007) to 0.67 (2014). Likewise, large local firms declined to 0.58 (2014) from 0.96 (2007). Small foreign firms posted a value of 0.7 (2014) but it is still lower than 0.88 achieved in 2007. The small local firms also dropped from 0.56 (2007) to 0.54 (2014).

Shortage of skilled workers, especially low and middle-level staff, has been one of the key factors affecting Malaysia's M&I industry. Findings from the interview sessions with corporate leaders from the industry reveals that M&I industry is unattractive to the local labour force due to their perception that it is a '3D' job (Dirty, Difficult and Dangerous). At present, these 3D jobs are usually filled by foreign workers looking for higher wages. In term of staff training, there is a mismatch between local graduates' competencies and industry needs. Therefore, academia, industry, government, and society all have major roles and responsibilities in resolving this gap in human capital.

12.3.2 Knowledge Systems and Leadership

In terms of leading and instituting formal approaches to knowledge management, the M&I industry performs better than the Malaysian aggregate in all the period from 2003 to 2014 (see **Figure 12.3**). However, the M&I industry aggregate showed a slight decrease in 2014 (0.62), compared to 2007 (0.64). Essentially, large foreign firms registered a sharp decline between 2007 and 2014 (from 0.9 to 0.56), and large local firms also shows a downward trend from 0.72 (MYKE II) to 0.67 (MYKE III). In contrast to the larger M&I firms, both foreign and local SMEs, show increased knowledge-leadership across the MYKE assessment period, in particular foreign SMEs (0.24 to 0.63 to 0.93) and local SMEs (0.31 to 0.47 to 0.58). This incremental improvement of operations (e.g., formulation of knowledge strategy and committee, and ISO certifications) in small M&I firms appears to be in response to the Malaysian Government's facilitative programmes for promoting industrial best practices. Although these processes are time consuming and costly, they are key to strengthening small M&I firms.

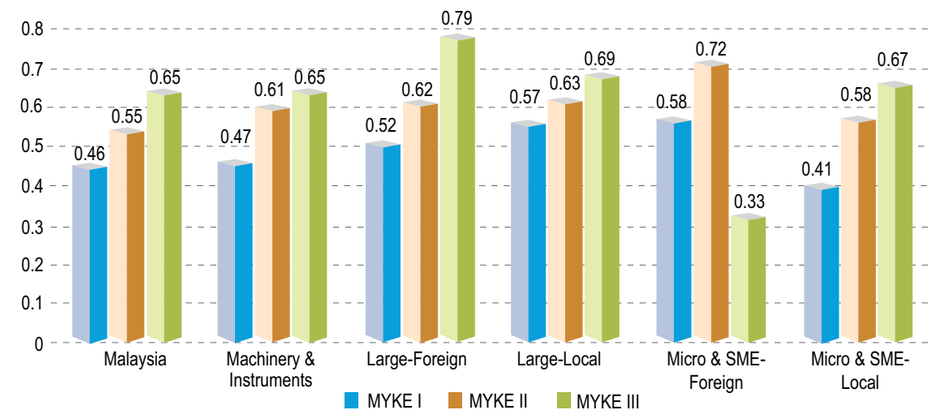
Figure 12.3: Knowledge Leadership in the M&I Industry

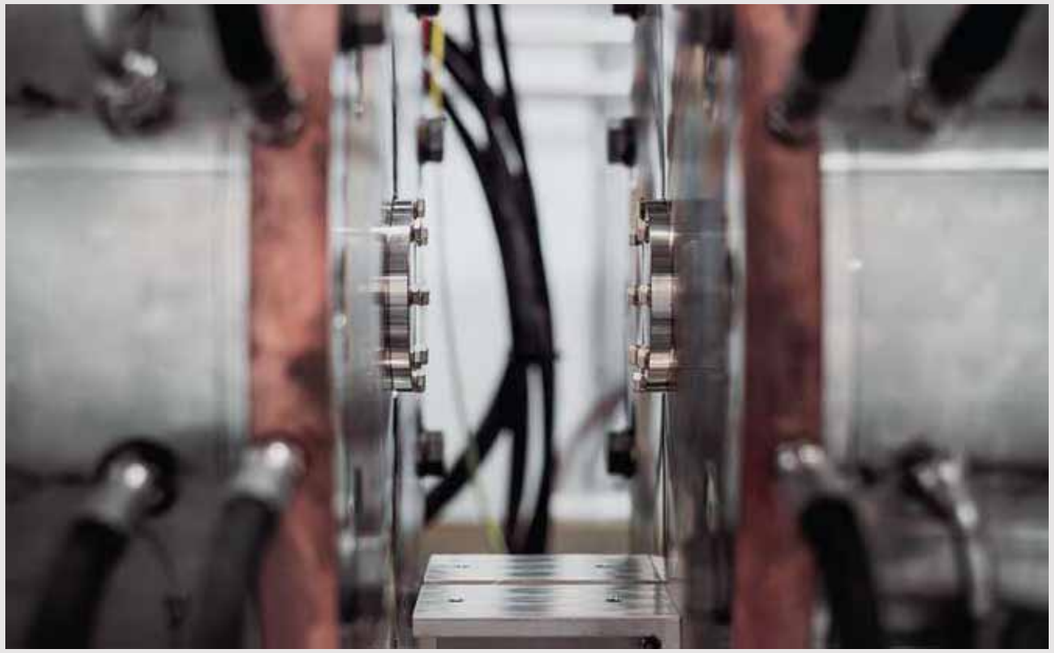


12.3.3 Technology and Infostructure

The technology-based infostructure of M&I firms is slightly better than the national aggregate and has improved consistently over the three MYKE periods, 0.47 (2003) to 0.61 (2007) to 0.65 (2014) (see **Figure 12.4**). All M&I firms, except foreign SMEs, improved their infostructure standards and provision. Large firms maintained a range from 0.52 to 0.79 over MYKE I, II and III. Local SMEs shows a consistent improvement from 0.41 (2003) to 0.58 (2007) to 0.67 (2014). This upward trend exhibits the local SMEs' commitment to technology infostructure, which has the potential of enhancing their organisational performance in a highly competitive M&I industry. In contrast, foreign SMEs decreased to 0.33 (2014) from 0.72 (2007), showing lower levels of computer investment and e-commerce adoption. Possible explanations are that these foreign SMEs have moved from traditional desktops to mobile communication technology, and have leveraged on social commerce platforms instead of e-commerce.

Figure 12.4: Technology and Infostructure of the M&I Industry

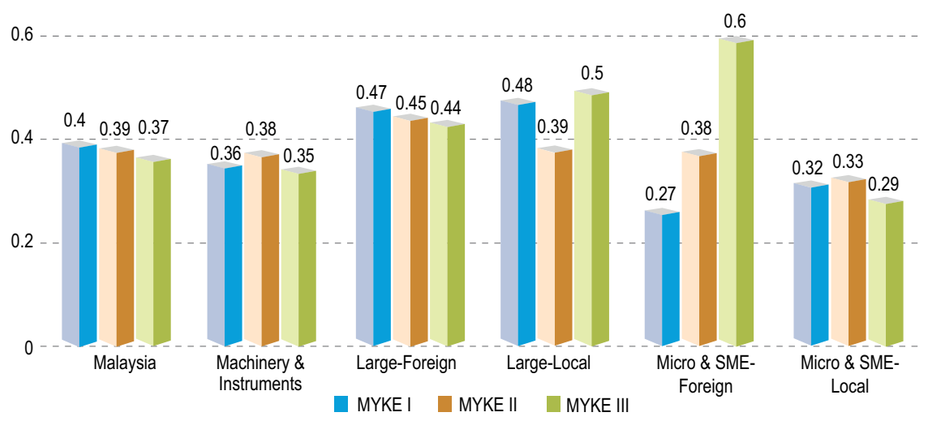




12.3.4 Knowledge Environment

At the aggregate level, M&I firms show lower level of engagement with universities, industries, government and associations, as reported by 0.36 (2003), 0.38 (2007) and 0.35 (2014) (see **Figure 12.5**). On closer analysis, the knowledge environment dimension of foreign SMEs is higher than large firms and local SMEs in 2014. Local large M&I firms, with improvement from 0.39 (2007) to 0.5 (2014), recognise the importance of universities, industries, government engagement to remain competitive in the M&I industry. In fact, some local industry associations such as Machinery and Equipment Manufacturers Association of Malaysia (MEMA) and Association of Consulting Engineers Malaysia (ACEM) have played a strong mediating role between the government and industry.

Figure 12.5: General Environment Awareness of the M&I Industry



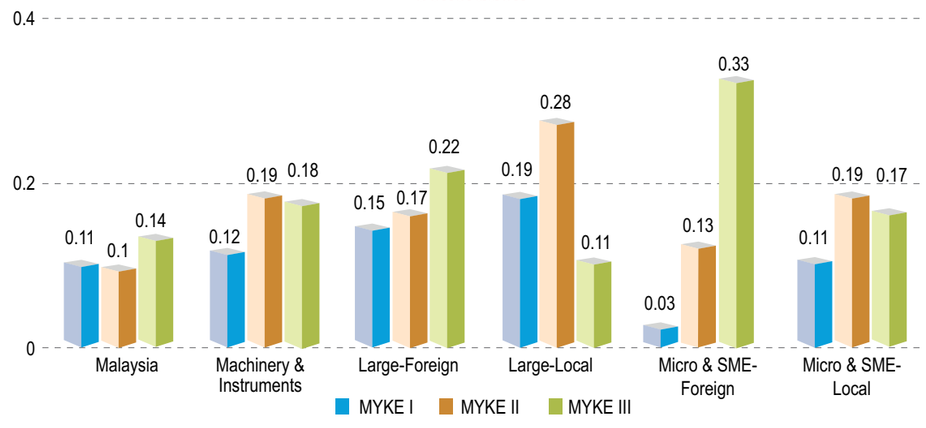
12.4 Knowledge Actions

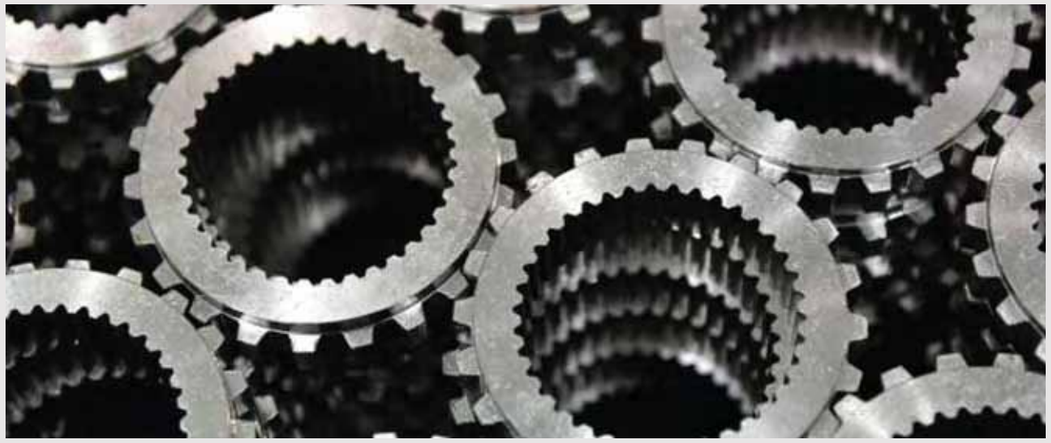
12.4.1 Knowledge Generation

As shown in **Figure 12.6**, the knowledge generation index in the M&I industry was above the national aggregate across MYKE I, II and III. However, the index is relatively low, registering at 0.12 (2003), 0.19 (2007) and 0.18 (2014). The survey found that foreign large firms have incrementally improved knowledge generation over the period, from 0.15 (2003) to 0.17 (2007) to 0.22 (2014). The foreign SMEs also experienced the same trend, increasing from 0.03 (2003) to 0.13 (2007) to 0.33 (2014). This pattern of improvement shows that foreign firms are currently undertaking R&D and intellectual property generation (e.g., patents and copyright filing) for M&I industry in Malaysia).

In 2014, the knowledge generation index for both large and small local M&I firms fell below that of foreign firms, recording at 0.11 (local large firm) to 0.17 (local small firm). Analysis from qualitative data shows that the local M&I firms are highly dependent on foreign technology (e.g., Germany and Japan) and import these technologies for their operations. The dependence on foreign technology undermines local firms' ability to create new knowledge and product and develop R&D capability. This is of concern because for the industry to be competitive, it should develop home-grown technology and intellectual property demanded by its domestic and global markets.

Figure 12.6: Knowledge Generation Activity in the M&I Industry



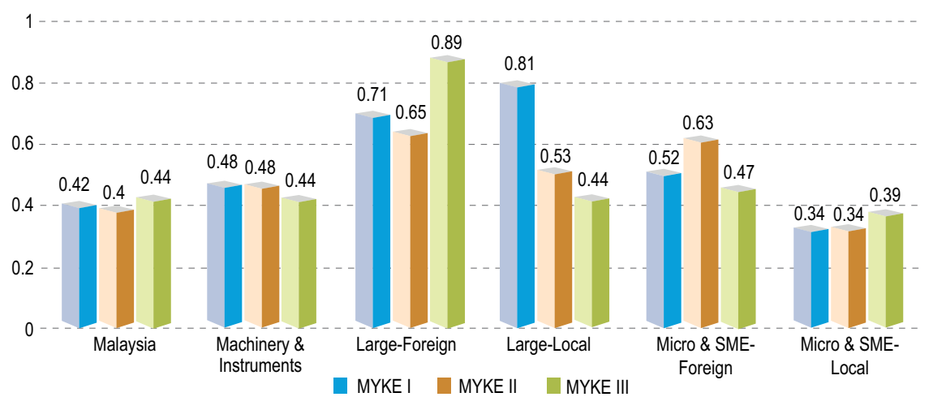


12.4.2 Knowledge Sharing

In MYKE assessment, knowledge sharing is measured using different types of engagement including use of project teams and online collaboration tools, as well as inter-organisational knowledge sharing. The knowledge sharing index in the M&I industry remained at 0.48 for 2003 and 2007, but declined to 0.44 in 2014 (see **Figure 12.7**). Overall, the M&I index was either above or on par with the national aggregate. However, the level of knowledge sharing differs between the types of M&I firms. Large foreign firms leaped from 0.65 (2007) to 0.89 (2014), whereas large local firms slipped to 0.44 (2014) from 0.53 (2007). Small firms persistently demonstrated a lower performance in knowledge sharing except for local SMEs which registered a slight increase, from 0.34 (MYKE II) to 0.39 (MYKE III).

These findings suggest that local small M&I firms have motivated their employees to engage in a process of knowledge sharing. The availability of the Internet and networking technology such as intranet services, portals, instant messaging and cloud computing have enabled small companies to connect with more technology savvy firms to enhance their knowledge sharing activities. In large foreign firms, knowledge sharing has become an important activity to increase the rates of businesses learning from their environment and incorporating knowledge into business.

Figure 12.7: Knowledge Sharing Activity of the M&I Industry

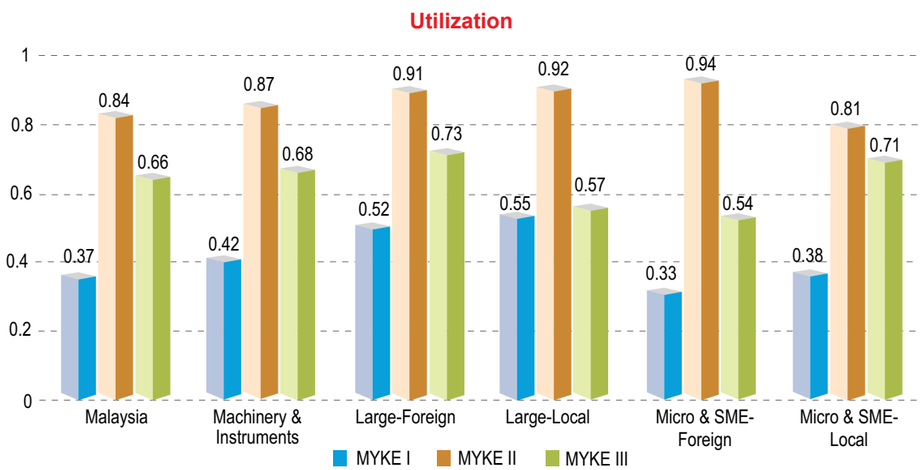


12.4.3 Knowledge Utilisation

The knowledge utilisation in M&I industry surpasses the national aggregate consistently in all assessment periods, though the gap has been successively declining across the time-series. All M&I firms, regardless of foreign, local or size, have made a strong progress in applying external and experiential knowledge from 2003 to 2007, as evidenced by 0.52 to 0.91 (for large foreign), 0.55 to 0.92 (for large local), 0.33 to 0.94 (for foreign SMEs) and 0.38 to 0.81 (for local SMEs). However, in 2014, all firms have reported a decline in knowledge utilisation (see **Figure 12.8**).

Most notably, large local M&I firms declined from 0.92 to 0.57 between 2007 and 2014. In the past, M&I products were mainly built from proprietary knowledge, which generated high profit margins. However, many M&I products have become commodities that are easily obtained from lower cost producers (e.g., manufacturers from China) with mostly similar features. Therefore, the large local M&I firms have paid less attention in knowledge utilisation for creating high value-added products. Instead, they have focused on operational cost optimisation and have additionally lowered profit margins to stay competitive. Interestingly, small local firms have kept pace with large foreign firms, achieving 0.71 in 2014. This improvement has shown that small local M&I manufacturers have the capability to apply knowledge to further develop existing technology to higher levels.

Figure 12.8: Knowledge Utilisation Activity of the M&I Industry

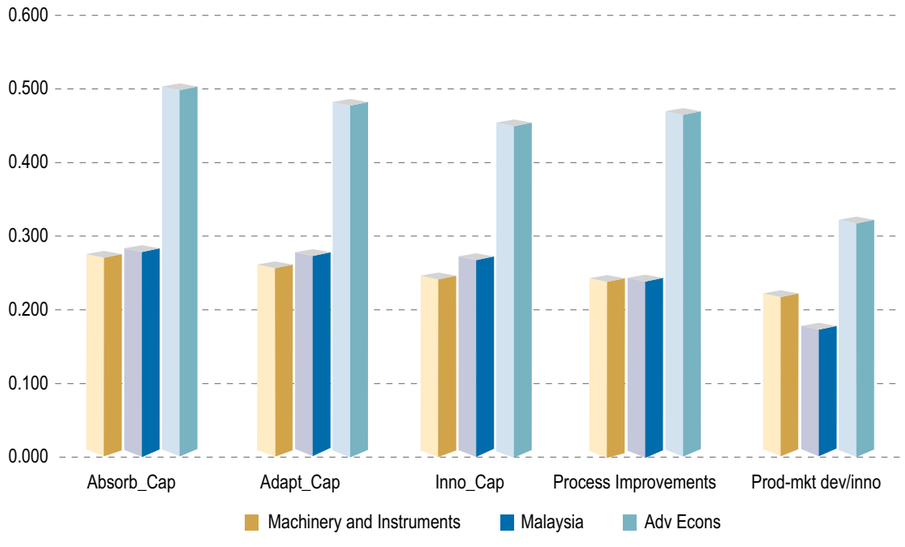


12.5 Dynamic Capabilities Profile for Machinery & Equipment Industry

Over the years, the M&I industry has been strengthening dynamic capabilities that reside in the firms' resources, processes and capabilities through several initiatives. Dynamic capabilities of firms can be classified into three components. Namely, they are: absorptive capability, adaptive capability and innovative capability. Companies that attain higher levels of dynamic capabilities are able to embrace change and stay competitive in the marketplace.

Figure 12.9 shows the M&I industry's dynamic capability profile, performance and innovation outcomes. Across all three dynamic capabilities, the M&I industry's performance is lower than the Malaysian industry aggregate. However, the industry's positive position in dynamic capabilities has resulted in process improvement that aligns with the national aggregate. Importantly, the industry achieved a high level of product-market development/innovation that is above the national aggregate.

Figure 12.9: Dynamic Capability Profile of the M&I Industry



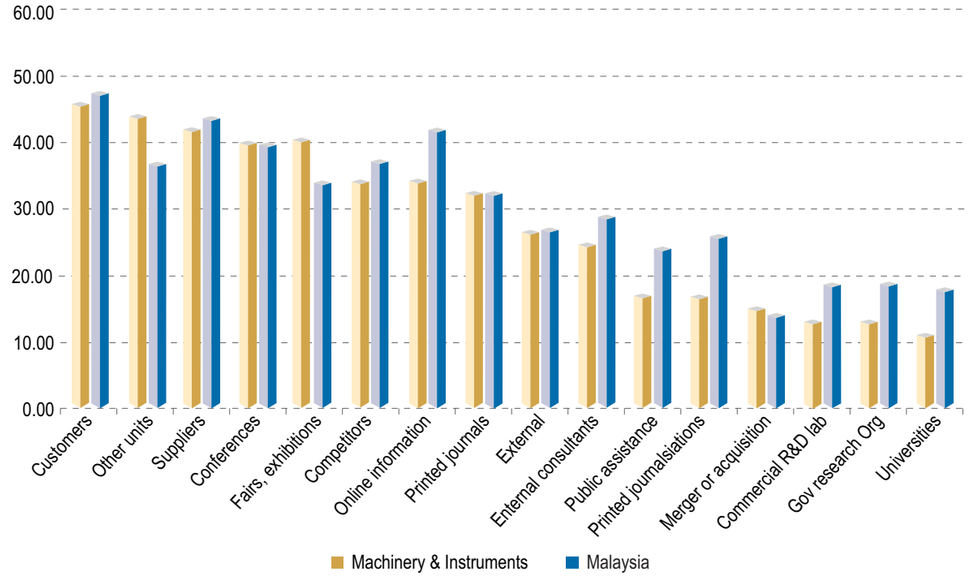
12.5.1 Absorptive Capability

Based on **Figure 12.10**, the top three sources of knowledge for M&I industry are customers, knowledge from within the firm itself, and suppliers. This shows that the M&I industry is active in collecting information from its customers, other units in the firms and suppliers, and is able to translate the information into knowledge to be shared across the firm. The industry seems to be customer-driven and firms are highly dependent on customers' feedback on their products. The industry also appears to be active in establishing strong linkages with its suppliers. Other major sources of knowledge absorption include conferences, fairs and exhibitions, as well as learning from competitors.

Application of research and development to the M&I industry is of critical importance. The low level of research and development, commercialisation and engagement with government research organisations and universities is of concern given the role of R&D as one of the key enablers in driving greater productivity and sustainability in the industry.

Overall, sources of knowledge for M&I firms are tapped at a higher level than the national aggregate.

Figure 12.10: Sources of Knowledge in the M&I Industry



12.5.2 Adaptive Capability

Adaptive capability represents how well firms are able to reconfigure resources and coordinate processes in response to structural and market changes. Measures for developing adaptive capability are multidimensional, including possession of adequate skills and expertise. **Figure 12.11** shows the skills profile of the M&I firms. Although the number is slightly lower than the Malaysian aggregate, business administration graduates constitute the largest group in the industry. This is followed by other groups in general engineering, electrical and electronic engineering, and computer science and software development. As expected, all of these hard-science groups feature at a higher level here compared to the national aggregate. The skills profile indicates that the M&I industry pays attention to the engineering and business skills base as important sources that help firms to build their adaptive capability. If appropriate measures are taken to enhance its human capability foundation, this industry has a strong potential to move up the knowledge value chain.

Malaysia is a dynamic country and its institutional environment plays a vital role in developing the M&I industry. In Malaysia, institutions such as universities, government agencies and industry associations offer a wide range of facilitating services to M&I firms.

Figure 12.12 shows that the M&I industry is below the national aggregate in all support and assistance, except assistance on standards and quality management. The top three assistances received by the M&I industry are namely, (1) provision of training, as well as educational and skills development; (2) finance, accounting and taxation; and (3) standards and quality management. It is surprising to note that the M&I appears to be less receptive to services on quality improvement, research and commercialisation. A possible explanation is that this industry relies on their existing firm-specific resources to perform quality improvement, research and commercialisation.

Figure 12.11: Skills Profile of the M&I Industry

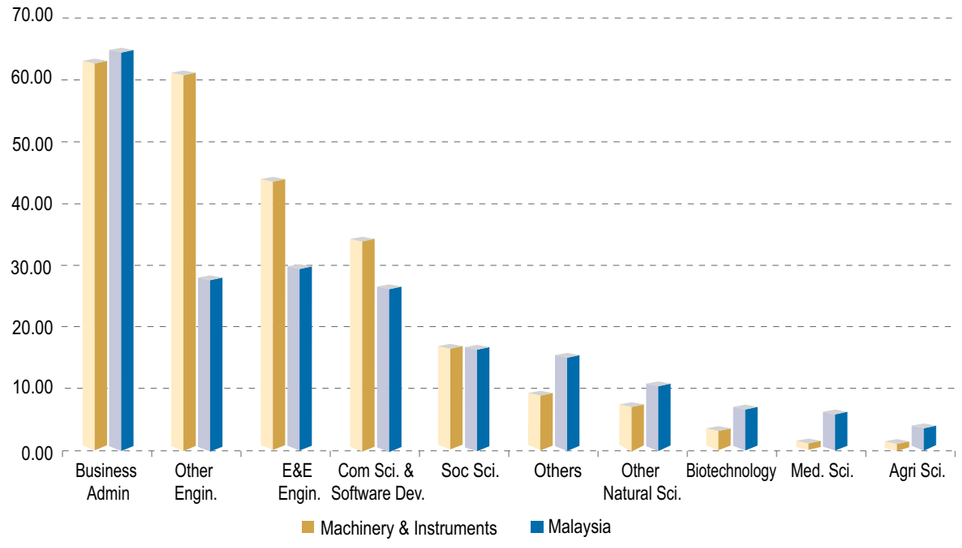


Figure 12.12: Role of Institutional Environment in Skill Building of the M&I Industry

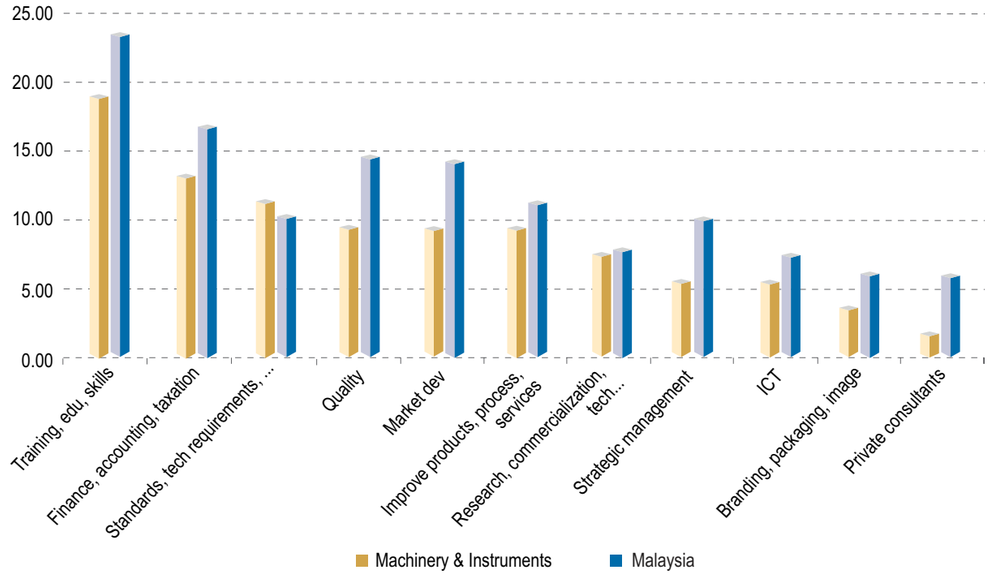
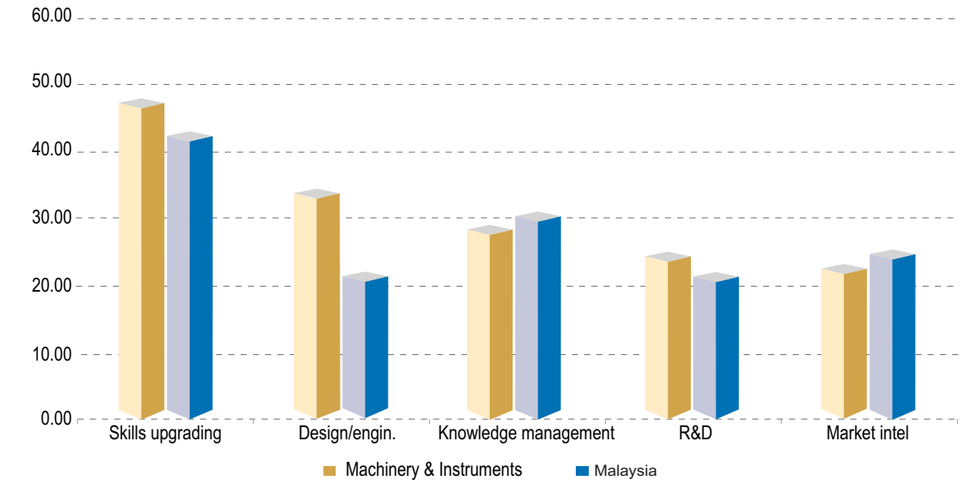


Figure 12.13: Knowledge Intensive Activities in the M&I Industry



12.5.3 Innovative Capability

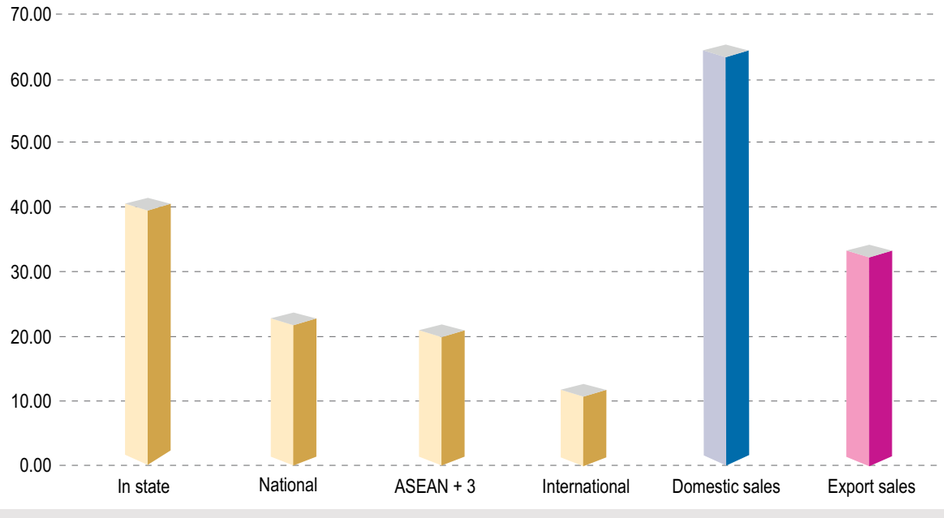
In general, the M&I industry engaged in a higher level of innovative capability initiatives, which is above the national aggregate (see **Figure 12.13**). In particular, the M&I firms are above the Malaysian aggregate in skills upgrading, design and engineering improvements, and research and development. This shows that firms in the industry are focusing on skills upgrading, design and engineering improvements, and research and development.

However, the industry falls short in terms of investment in knowledge intensive activities like knowledge management and market intelligence that are important to improve their capability to develop market-oriented products.

12.6 Outcomes of Dynamic Capabilities in the Machinery & Equipment Industry

The market presence of Malaysian M&I industry shows that it is primarily domestic-based, with 65.31% of revenues generated from the home market. Within the state, sales revenue contributes 41.71%, indicating the positive impacts of government-led initiatives and corridor plans. Export sales account for 34.69%, with 22.02% from the regional market (ASEAN plus Japan, China and South Korea) and 12.67% from international market. This indicates that Malaysian M&I firms are not highly competitive in the global market.

Figure 12.14: Market Presence of the M&I Industry

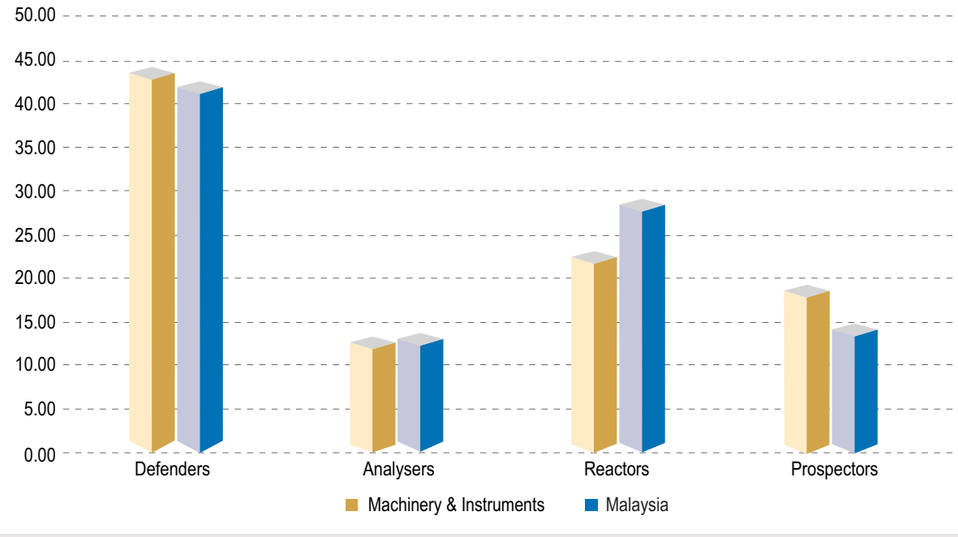


Note: The results are based on survey data.

As shown in **Figure 12.15**, the M&I industry's strategic profile has a strong presence of firms that are Defenders (44.23%), followed by Reactors (23.08%), Prospectors (19.23%) and Analysers (13.46%). Defender firms focus on efficiency-based strategy by deliberately selecting a stable and defined market domain. Reactor firms are firms with limited adaptive capability to respond to market changes. Prospectors firms are risk-takers, and actively conduct research and communicate with the market. Analyser firms stay in a stable market domain, but they adopt new ideas through environmental scanning. The M&I industry has more Defenders and Prospectors firms than the national aggregate, but lower than the aggregate number of Analyser and Reactors.

The profile of the industry shows that firms in the industry are largely Defenders that attempt for high market share in their domain, and Reactors who are unresponsive to external changes in their environment.

Figure 12.15: Strategic Profile of Firms in the M&I Industry

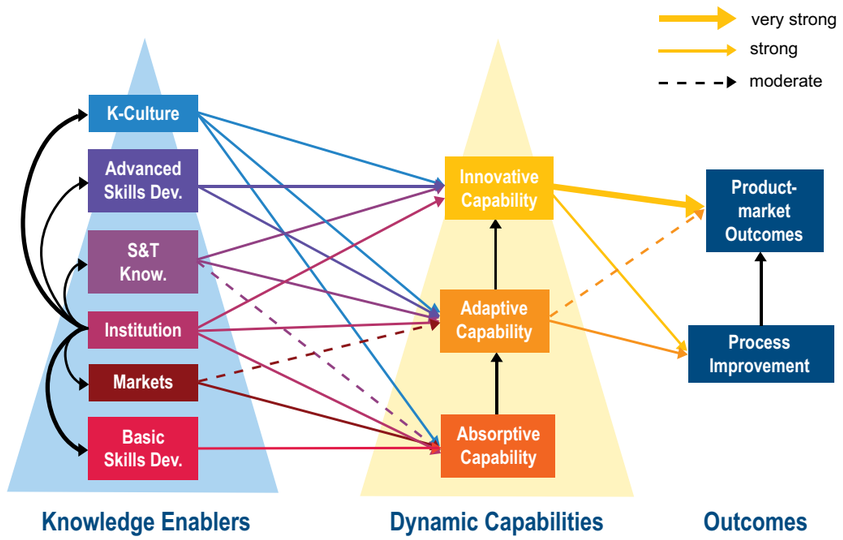


12.7 Relationships between the Key Blueprints of the Machinery and Instruments Knowledge Ecosystem

We next discuss the relationship between the knowledge enablers, dynamic capabilities and economic outcomes for the machinery and instruments industry. The Malaysian machinery and instruments knowledge ecosystem is examined relative to its advanced sector country counterparts (i.e., Brazil, Canada, Germany, Turkey, and United States). Based on prior examination of these advanced sector countries and the data collected by DOS specifically for the Malaysian machinery and instruments industry, it is possible to draw a benchmark comparison. Relative to advanced sector country benchmarks, the Malaysian machinery and instruments industry is rated as an Imitator in terms of knowledge content and outcomes.

Figure 12.16 shows the machinery and instruments knowledge ecosystem for advanced sector countries. In the advanced sector countries, enablers for all three components of the dynamic capability are very rich and strong in their nurturance of dynamic capabilities. The machinery and instruments in these countries possess a strong absorbability capability foundation that feeds into and enriches both adaptive and innovative capabilities for the industries. Having strength in absorptive, adaptive and innovative capabilities allows them to develop highly efficient new processes as well as generate significant level of new product innovations. These outcomes create ripple effects into down-stream industries ensuring that the national ecosystem is fully connected for global competitiveness.The machinery and instruments knowledge ecosystem for Malaysia is shown in **Figure 12.17**. The Malaysian machinery and instruments knowledge system shows that enablers to support dynamic capability components are weak and unable to create sufficient depth in these capabilities so as to produce strong outcomes. A comparative summary of the strength of the machinery and instruments ecosystems in advanced sector countries and in Malaysia is provided in **Table 12.4.**

Figure 12.16: Knowledge Ecosystem of the Machinery and Instruments Industry in Advanced Country



Note: Very strong impacts are represented by the bolded line, strong impacts are represented by normal lines and moderate impacts are represented by dotted lines.

Figure 12.17: Knowledge Ecosystem of Machinery and Instruments Industry in Malaysia

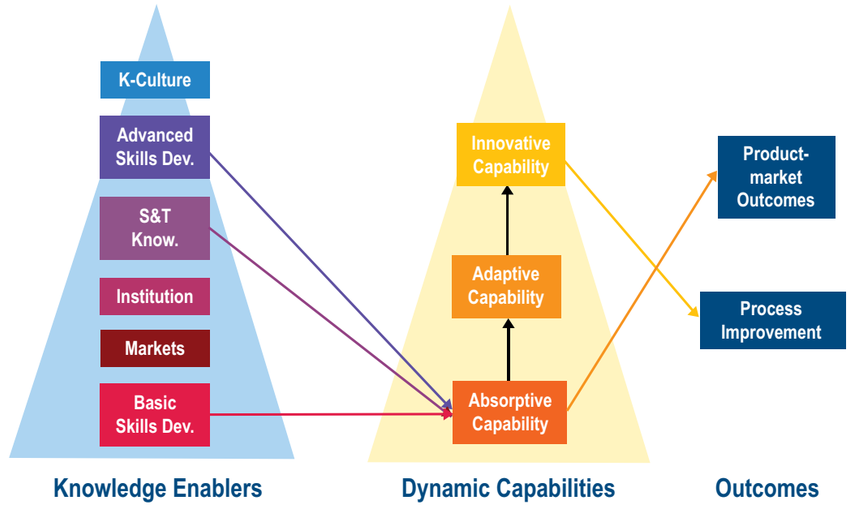


Table 12.4: Knowledge Enablers and Dynamic Capabilities for the Machinery and Instruments Industry

Advanced Countries	Malaysia
Basic skills have a **positive and strong impact** on absorptive capability The machinery and instruments industry in advanced sector countries is an important source of revenue. Significant investments are made to ensure that engineering, science and technical skills are continuously improved through constant updating of knowledge in curriculums offered by technical colleges, polytechnics and universities. Being technology and knowledge intensive, machinery and instruments industry of advanced sector countries undergoes continuous change. Due to technological and scientific shifts, firms in the industry need to keep up with change. This is achieved through close collaboration with educational institutions and other agencies. Training and updating of the workforce is a regular feature in their effort to maintain a global lead and competitiveness.	Basic skills have a **significant impact** on absorptive capability. The Malaysian machinery and instruments industry remains labour intensive and employs significant number of foreign labour from neighbouring countries. There is some reluctance to invest heavily in training and development given the transient nature of the workforce. Nonetheless, certain level of training is necessary to ensure productive use of the workforce. The skills levels within the industry range from middle to low. Reliance on foreign workers creates leakage in the system when permits expire, especially when a number of foreign workers acquire much needed skills over time and experience.
Market intelligence has a **positive and strong impact** on absorptive capability; and **positive and moderate impact** on adaptive capability.	Market intelligence **has no significant impact** on any of the dynamic capabilities.

Table 12.4: Knowledge Enablers and Dynamic Capabilities for the Machinery and Instruments Industry (cont'd)

Advanced Countries	Malaysia
Suppliers, customers, competitors, external consultants and R&D centres collaborate proactively and facilitate the process of absorption and adaptation of new knowledge, technology, systems and processes. Productive efficiency and new technologies are key drivers of the industry. These are driven by significant investment in R&D by both public and private institutions, backed by sound IP regulations in the industry. Strong market orientation of firms keeps the industry in touch with upstream and downstream shifts and allows effective leverage of new technology, innovations and scientific discoveries for marketplace positioning.	The general focus in the industry is price competitiveness. Interactions among the key stakeholders are patchy and fragmented. The driving force of change is the downstream supply chain and upstream technology. Markets are perceived to be price sensitive, thus the end goal is one of being able to imitate others offerings at the lowest cost possible.
Institutions are **strong enablers** of the knowledge ecosystem and have **direct strong and positive impact** on all three dynamic capability components. In advanced sector countries, there is a rich tapestry of support from the state and local bodies to ensure that the different institutions come together to create forceful positive impact upon the machinery and instruments industry. There is a strong focus on developing engineering and science capabilities. A significant level of incentives (fiscal and non-fiscal) is provided to research institutions, universities, regulators and trade associations to allow them to work closely with each other and dovetail their strengths to maximise the impact of development on a vibrant and strong machinery and instruments ecosystem. This facilitates development of strong firm level dynamic capabilities.	Institutions have an indirect **impact on the enablers,** but no **significant impact** the three dynamic capability components directly. Key institutions, such as the regulators, trade association, universities and government agencies, are important players in the development of machinery and instruments industry, but these institutions are unable to sufficiently materialise the development of dynamic capability components. One of the key challenges is to attract and retain the quantity and quality of intellectual capital within the industry. Perceptions of the industry as a "3Ds sector" prevail and over time fewer and fewer individuals pursue science engineering careers. This makes it difficult for machinery and instruments enterprises to get the requisite quantum and quality of talent from the pipeline of local human capital base.
S&T knowledge has a **positive and moderate impact** on absorptive capability, and a positive and strong impact on adaptive and innovative capabilities. In advanced sector countries, basic and applied R&D activities in the STEM are very strong. They are highly focussed on key strategic areas and bring together upstream and downstream industries to mutually reinforce each other's advantage. Significant resources are invested to	S&T knowledge has a **positive and strong impac**t on absorptive capability. R&D in the machinery and instruments is relatively weak. Lack of talented staff in key research priority areas and weak industry-university partnerships have led to a situation where the majority of the firms in the industry are dependent on foreign know-how and technology in the running of their operations. Much of the S&T knowledge that exists

Table 12.4: Knowledge Enablers and Dynamic Capabilities for the Machinery and Instruments Industry (cont'd)

Advanced Countries	Malaysia
ensure the global competitiveness of the industry. These actions include continuous upgrading of technological infrastructure and R&D capabilities of leading research centres and universities. This provides machinery and instruments enterprises easy access to leading edge fundamental advances. There is also strong provision to facilitate R&D and commercialisation between research universities and industries. University-government-industry partnerships are dovetailed to ensure R&D undertaken is relevant to the needs of all stakeholders. Provisions are also made to build stronger and stable SMEs to allow a sound footing whilst supporting bigger players to enhance their global reach.	is directed toward improving absorptive capacity of firms in the industry. Many of the firms, especially SMEs, do not have the financial resources to undertake R&D and thereby move up the value chain. Most Malaysian firms are risk averse and prefer to use technology that has already been used elsewhere. As such, a large portion of resources is invested to train workers, engineers and technologists to simply use existing foreign technology.
Advanced skills have a **positive and strong impact** on innovative and adaptive capabilities. In advanced sector countries, significant resources are invested to not only strengthen the fundamental STEM research but also into potential derivative applications arising out of the advances. Once high level skills are developed, there are substantial incentive schemes to attract and retain the best talent within the industry. Strong engagement between universities and industry ensure these countries are able to translate R&D advances and bring them out of the lab into the commercial sector as viable products and services. Strong linkages between key stakeholders bridge the 'knowledge-commercialisation chasm' and enable enhancement of adaptive and innovative capabilities of the industry.	Advanced skills have **a positive and significant** impact on absorptive capability. Even though considerable effort has been made to increase R&D activities and improve advanced skills, employees in Malaysian enterprises continue to adapt existing technology or knowledge developed by foreign research centres or MNCs. With very few local firms engaging in cutting-edge R&D or innovative endeavours, the very best of Malaysian talent finds that they are able to deploy their skills to greater effect in foreign MNCS. Some even migrate to more advanced countries where opportunities to undertake cutting-edge R&D are more readily available and career prospects are much better. The lack of highly specialised challenging tasks and environment within which individuals can exercise their advanced skills contributes to the 'brain-drain' problem, which hinders building higher level adaptive and innovative capabilities.
Knowledge culture has a **positive and strong impact** on all three dynamic capabilities. A culture of knowledge sharing and working together with different parties internal and external to the firm features strongly in the operations of	Knowledge culture has a **no significant impact** on all three components of dynamic capability. The level of knowledge competency and sharing among key stakeholders is relatively low. Lacking a strong base of differentiated products, an intense

Table 12.4: Knowledge Enablers and Dynamic Capabilities for the Machinery and Instruments Industry (cont'd)

Advanced Countries	Malaysia
machinery and instruments players in advanced sector countries. Industry players, universities, and agencies are all well informed about key technical developments, market conditions and innovations taking place in domestic and global markets. There is strong coupling between government agencies, trade/industry associations and universities to ensure strong flows of knowledge and sharing of best practices. Access to information and data from government and trade associations is strongly facilitated and considerable information and knowledge processing takes to drive informed choices and decisions.	competitive mentality pervades the industry. This position is worsened by a culture of dependency among the enterprises, especially among SMEs, on government, suppliers or other intermediaries for information, technology and knowledge. A number of factors hinder innovative capability of the industry. First, a number of firms are simply too complacent to engage in the arduous and uncertain task of R&D-led innovation. It is much easier to copy and imitate. Compounding this, a good number lack the financial wherewithal even if they are willing to take the risks of R&D activities. On top of this, the handful of entrepreneurs who do manage to create IP attempt to monetise upon it quickly by selling it to third parties, since they feel they lack the resources, stamina and long term orientation required to develop the high returns from their IP. Fourth, market failures such as weak protection of IP perpetuated by leakages by intermediaries hinder sharing of best practices across the industry. This breeds an insular culture in which there is inherent lack of trust in employees and the industry ecosystem.
The continuum from absorptive capability to adaptive capability to innovative capability is **present and strong.** In advanced sector countries, the machinery and instruments industry is perceived to be a critical driver of the manufacturing sector and hence features strongly within their national strategic priorities. As a result, significant resources are channelled to ensure the machinery and instruments industry remains productive and globally competitive. Such focus is the basis in nurturing strong capability building efforts to ensure that all components aspects of the industry mutually reinforce each other for competitive advantage.	The continuum from absorptive capability to adaptive capability to innovative capability **is present.** While there is considerable investment to strengthen the capability of firms in the machinery and instruments industry, there remain significant weaknesses in the nature and strength of dynamic capabilities created. Unfortunately for local firms, the best talent in Malaysia is often recruited by MNCs, who are able to offer organisational environments and rewards commensurate with their skills. Due to the lack of R&D endeavour among local firms, many employees, even when they possess the skills for innovation, are focussed upon modifying foreign technology for local and regional demand. This risk averse nature of local firms leads them to become providers of services and support to foreign firms engaged in innovative endeavour. Ultimately, the IP and patents are owned by foreign firms, which creates a vicious cycle of higher dependency.

The impact of dynamic capabilities on economic outcomes for the machinery and instruments industries for both advanced sector countries and Malaysia is summarised in **Table 12.5**. In advanced sector countries, adaptive capability was found to have a positive and strong impact on process improvements; and a positive and moderate impact on product market outcomes. On the other hand, innovative capability was found to have a positive and strong impact on process improvement and a very strong influence on product market outcomes. Additionally, process innovation has a strong feed into the development of improved product offerings. The machinery and instruments industry in advanced sector countries is an important industry characterised by efficient production and product innovations.

Evidence from data collected for Malaysian machinery and instruments industry shows that absorptive capability influences the release of product innovations that are imitative copies of others' products. The focus of innovative capability is geared primarily towards process improvement. The mainstay focus of the highest level dynamic capability component, namely innovative capability, of the machinery and instruments industry is to reduce costs of production of imitative products. To meet this aim, firms in the industry utilise a range of strategies, from using cheap foreign labour, buying others technology and innovations to drive their systems and processes to reduce costs. The inherent innovation weaknesses of the machinery and instruments ripple across into downstream industries and limit the potential of manufacturing sectors that are reliant on machinery and instruments upstream operations.

Table 12.5: Dynamic Capabilities and Economic Outcomes for the Machinery and Instruments Industry

Advanced Countries	Malaysia
Adaptive capability has a **positive and strong impact** on process improvement and a positive and moderate impact on product market development. There are a wide range of firms that operate at different levels of the innovation value chain. A significant number of SMEs innovation drivers, using their small size and entrepreneurial zest to nimbly seize opportunities. They are particularly adept in using new technology and innovations to improve existing products and services. Possessing strong capabilities, they are able to play a key role in supplying innovative products and services for the larger MNCs in the industry.	Absorptive capability has a p**ositive and strong impact** on product-market innovation. Locals firms build their capability by leveraging on knowledge and technology developed in more advanced sector countries. With only absorptive capability driving product innovations, downstream sectors of the machinery and instrument receive imitative products and services. Foreign technology and innovations are absorbed and used to churn out products that are generic versions of others innovations.
Innovative capability has a **positive and strong impact** on process improvement and a positive and very strong impact on product market outcomes. There is significant investment in R&D and skilled workforce by government institutions, universities for the upstream and downstream industries. This enables firms to produce more efficiently and at the same time introduce new innovations, products and services. Many of the firms have global reach and brand presence.	Innovative capability **has positive significant impact** on process improvement but not on product market development. Most local firms adopt new technology and innovations from more advanced sector countries to improve cost-efficiency and meet domestic market demand. Little R&D and innovation takes place.

Table 12.5: Dynamic Capabilities and Economic Outcomes for the Machinery and Instruments Industry (cont'd)

Advanced Countries	Malaysia
Process improvement leads to strong **positive impact** on product market outcomes. The machinery and instruments industry is driven by a strong linkage between process innovation and product innovation. Product and service innovations of the industry are delivered at a highly cost competitive basis as a consequence of a strong focus on continuous improvement of technology and manufacturing processes. This enables firms to translate process improvements into new product introductions.	Process improvement **does not impact** product market outcomes. Process improvements undertaken by firms in the industry are based on foreign technology, IP or services provided by foreign firms. This constrains local firms' potential to create new products and services.

12.8 Summary: Key Trends, Challenges, Way Forward and Best Practices

12.8.1 Industry Trends

The dynamic capabilities of the M&I industry are slightly lower than the national aggregate. Nonetheless, the industry is making positive progress in process improvement and product-market development and innovation. Compared with the Malaysian aggregate, the M&I industry possesses a lower level of absorptive capability, adaptive capability and innovative capability.

The M&I industry is an important pillar for the manufacturing industry, and is strongly technology-driven. Recognition of the importance of this industry to other technology-intensive industries has culminated in the development of incentives and programs put under the three Industrial Master Plans and five-year economic plans.

As stronger trade ties are conceived across the globe, competition from advanced sector countries, such as Japan, US, Germany, and more recently, China, have reduced the attractiveness of domestic products. However, domestic firms that are able to buy foreign technologies and build upon these capabilities are becoming formidable contenders in their own right. As the technology in this industry transform rapidly, domestic firms need to increase their knowledge capability to remain relevant to the global M&I landscape.

12.8.2 Challenges

The M&I industry has undergone rapid transformation due to major technological breakthroughs and converging technology platforms. While these changes have opened new opportunities for firms globally, many Malaysian firms face challenges in moving up the knowledge and innovation value chain. The challenges encountered by the firms are discussed below.

Institutions:

- Lack of leadership and local large players that are able to spearhead initiatives, improvement and developments of the Malaysian industry.
- Insufficient financial and advocacy support for the industry has an adverse impact on SMEs within the industry.
- Facilitative programs are poorly implemented and tedious.
- Increasing cost of raw materials and doing business deters new business ventures, and also causes leading firms to move out to neighbouring countries.
- Lack of collaboration and interaction between industry, associations, universities and other stakeholders – encouraging a "silo" mentality and culture in the industry. This prevents institutions from developing collectively a strategic and implementation plan to enhance knowledge component in this industry.

Basic Skills Development:

- Basic skills development is primarily driven by large and foreign firms.
- Heavy reliance of foreign workers due to the nature of the work and environment (3D). Workforce retention becomes a major issue due to work permit conditions and language barrier.
- Significant resources invested in technical colleges – but training programs do not always meet the needs of the industry, creating a mismatch between supply and demand in skills for the M&I industry.
- Lack local technical competent trainers result in high cost of training.

Advanced Skills Development:

- Firms do not invest in advanced capability development programs to nurture creative talent.
- Industry also experienced "brain-drain" to other industries and to more advanced countries.
- Lack of highly specialised talent and scientific 'know-how' to mentor and develop local talent.

S&T Knowledge:

- Skills of graduates do not meet the needs of workers in the industry. Most S&T graduates are good users of foreign S&T and not creators of new innovations.
- SMEs have major challenges recruiting high calibre workers. Most qualified individuals prefer to work overseas or with MNCs.
- SMEs face financial constraints to undertake R&D activities.
- Under-utilisation of the S&T due to institutional weaknesses – lack expertise and inadequate training to continuously upgrade talent and skills.
- Industry focuses on cost reduction instead of focusing on long term development of S&T knowledge workforce.

Market Intelligence:

- Collaboration and networking among key stakeholders is not well established.
- Low utilisation of technology, especially ICT, hinders firms' capabilities to extend their reach to valuable market information and intelligence.
- Lack of demand for local products discourages local manufactures from improving their capabilities – firms do not get valuable feedback from consumers.

Knowledge Culture:

- Lack of investment in appropriate technology and other support services hinders the translation of tacit knowledge into explicit knowledge.
- Lack of internal R&D initiatives results in firms becoming reliant on foreign firms for technology and innovations or at best undertake marginal innovations only.
- Lack of sharing among firms and key institutions results in the industry being unable to realise the multiplier effect of R&D and technology investment.

- Small firms are unable to codify knowledge (e.g., through ISO certification) due to a lack of time, people and resources.

12.8.3 Way Forward

The M&I industry is an important industry for Malaysia's industrial development, as it is not only a revenue generator for the economy, but also a key enabler for other industries, especially manufacturing. To strengthen the competitive position of this industry vis-à-vis industries from more developed countries, the M&I industry knowledge ecosystems should be further strengthened. The discussion below provides recommendations to enhance the M&I industry knowledge ecosystem.

Recommendation 12.1: Focus Development of Frontier M&I Technologies that will Power Malaysia's 4.0 Industry (My4.0I)

- Key stakeholders in the industry should work together to focus R&D activities in technologies that will power Malaysia's 4th Industrial Revolution, which includes developing next generation machines and instrumentation that incorporate the Cyber-Physical System and Embedded Systems & Networks. This will include M&I industries that incorporate the following design principles:
  - *Interoperability* – machines and devices that are connected and communicate ubiquitously with devices and people;
  - *Virtualisation* - ability to create virtual reality of the physical world with high degree of precision to enable simulations and decision making process.
  - *Technical assistance/Service Orientation:* ability to collate information from multiple sources and assist informed decision-making, meet the need of individual customers and solve urgent challenges in a relatively short period of time and enable task completion in difficult and hazardous conditions.
  - *Real-time Capability* – ability to make instantaneous decisions via communication network, which reduces wastage and downtime of machines.
  - *Decentralise decisions:* using digital systems to make decision autonomously, quickly and accurately using artificial intelligence methods and other human-machine interface systems.
- Ensure next generation M&I cluster is core to the remaining 20 industries, in particular the automotive, transport equipment, E&E, healthcare and construction industries.
- Establish leading centres of excellence in the above-mentioned areas to enhance R&D activities, jointly with leading firms & research institutes across the globe.

Recommendation 12.2: Train and Nurture Talent for the Next Generation M&I Industry

- Courses in universities and colleges should include fields that will transform the M&I industry into a high-tech and knowledge-intensive industry supporting My4.0I. This include the following: computer-integrated manufacturing; digital modelling and fabrication; industrial control systems; industrial internet; intelligence maintenance systems; internet of things; machine to machine language; predictive manufacturing; remote monitoring and control (supervisory control and data acquisition); and big data analytics, human-machine interfaces, robotics, augmented reality, artificial intelligence and design, and 3D-printing.
- Major refinements in the course curriculum in the TEVT programs in colleges and polytechnics are required to ensure the Malaysia has adequate technical workers who are able to be employed in the next generation industrial plants and smart factories.
- Industry Associations in partnership with colleges and universities should conduct affordable professionally certified and accredited programs to up skill the workforce in the M&I industry.
- An example is the collaboration between GMI and the ifactory 4.0 Innovation Centre to incorporate training of German industry 4.0 standards for smart moulds, smart maintenance and smart automation cell. The trainings should be intensified across all industries.

Recommendation 12.3: Supportive M&I Ecosystem to Enable SMEs to become Knowledge Intensive

- Establish a strong institutional alliance consisting of industry, scientific institutions, GRIs, industry associations and government agencies to assist SMEs and start-ups to implement the My4.0I initiative to achieve the following:
  - Create new value and business models to develop and provide downstream services.
  - Create common open standards to enable these firms to adopt standards that reduce production management efforts, link up with other major players and respond to market needs quickly.
  - Develop flexible value chain that enables working across multiple industries, businesses and locations; and provide personalised services.
  - Work closely with research institutes and universities to develop innovative products and services that meet both local and international standards.
  - Establish institutes and centres that will transfer Industry4.0 solutions across diverse industries and SMEs.
  - Establish a national agency that becomes an information resources centre and 'help-desk' for firms, workers, entrepreneurs, industry associations, academic and researchers on the implementation of Industry4.0.
  - Establish an affordable large-scale prototyping and testing facility in Malaysia.
- Government and GLCs to become key users and promoters of domestic technology.
- SIRIM certification approval processes should be simplified and made business-friendly. Furthermore, the standards that currently only apply to local products should also apply to foreign products in order to create a level playing field.

12.8.4 Best Practices

The global M&I industry is developing rapidly due to technological improvements and innovations over the last decade. Pace setter countries have continuously improved their ecosystems to ensure that firms in the industry have seamlessly integrated their operations, enabling them to improve their productivity, efficiency and market reach. These strategies and polices have assisted firms in these countries to pursue economies of scale and scope. Below are the best practices in the M&I industry that have been adopted in pace-setter countries.

Best Practice 12.1: Focus Development of Frontier M&I Technologies that will Power Malaysia's 4.0 Industry (My4.0I)

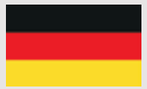
INDUSTRIE 4.0: Smart Manufacturing for the Future, Germany

- Germany has established a very strong platform for Industrie4.0 comprising of key government agencies, industry, universities, federations and research institutes to roll out Industrie4.0 – common vision and implantation strategy by all institutions has increased the adoption of Industry4.0 among German M&I firms.
- Close to Euro 200 million was allocated for Industry4.0 to spearhead smart machines and instruments that incorporate embedded systems with links to electronics, communication technology and microsystems technology.

- These new machines and instruments become the building-block of smart products, procedures and processes; which support Smart Factory, Smart Infrastructure and next generation industries (Agriculture, automotive, health care, etc.).

- Leveraging on the strength in engineering and technology related areas, Industrie4.0 is envisaged to help Germany be lead provider of cyber-physical (Smart) systems by 2020.

Best Practice 12.2: Train and Nurture Talent for the Next Generation M&I Industry



Fraunhofer-GesellSchaft, Germany powering translational R&D

- This institution undertakes applied R&D that is relevant to future development of industry and has a broader impact on society. Among them include frontier areas R&D, such as Production4.0, Human-Machine, virtual reality, encryption additive manufacturing, innovative batteries and other smart technologies.

- The Institute also focuses on developing global research and innovation leadership in 6 fields of research; they are health and environment; security and protection; mobility and transportation; energy and resources; production and supply services; and, communication and knowledge.

- The Institute also hosts 20 innovation clusters that work with leading industries and SMEs in Germany and across the globe.

- Has 66 institutes, more than 22,000 staff who are engineers and scientists with an annual budget of Euro 1.9 billion, of which Euro 1.6 billion is generated via contract research.

- The institute undertake studies for industry partners on a wide range of studies and analysis such as: custom-designed studies; feasibility and acceptance studies; market and trend analysis and host of other studies.

- The Institute also hosts some of the most advanced testing facilities and accredited test laboratories, which is open to firms. On-site training is provided and verification is provided for meeting specified industry standards.

Best Practice 12.3: Supportive M&I Ecosystem to Enable SMEs to become Knowledge Intensive

Productivity 4.0 Taiwan (Taiwan's version of Industry 4.0)

- Strong foundations in precision machinery and ICT technology, Productivity 4.0 helped transform Taiwan into a hub for Smart Machines.

- Intense capability enhancement program was introduced to enhance the productivity of SMEs by appointing experienced experts and mentors to adopt Productivity 4.0, solutions and platforms.

- Introduce a SME Service Network and Mutual Assistance Mechanism across the different counties and cities supported by the various chambers of commerce, Provincial Federation of Industries and Chinese National Federation of Industries.

- Matchmaking with leading industries across the globe – organise forums between Taiwanese firms and European firms, located in 23 priority industrial clusters for potential collaborations.
  - Key collaborations include: Siemens-Productivity4.0 Promotion Office; SAP-Taiwanese Manufacturer Join Hand for Industry 4.0 Factory; Fair Friend Group and 13 German Manufacturers from Industry 4.0 Strategic Partners; TongTai-Siemens Cooperation for Aerospace Machine Industry.

- Introduced a comprehensive financial ecosystem to support SMEs, which include:
  - One-Stop Service Centre – financial analysis & management, government information for SMEs and debt negotiation.
  - SME Credit Guarantee Fund.
  - SME Direct Investment Scheme – establish Investment Service Office to match investment, National development fund (NTD10 billion) and co-invest with venture capital scheme.
  - Financial Management Assistance – financial education, strategy consultation, training, certification and improving SME Financial and Accounting Systems.

- One Town One Industry Project – Local Industry Development Fund to nurture local industry culture to adopt best practices, including embrace Productivity 4.0.

- Start-up Taiwan Accelerator Program:
  - Mentoring – coaching at all levels of the value chain.
  - Funding – integrated funding sources.
  - Networking – matchmaking with key strategic partners and global connection.
  - Start-up and Incubation Programs – established mechanisms for supporting, strengthening and developing entrepreneurial acumen.
  - Youth Start-up programs.
  - One-stop portal, one-stop Start-up Hub and Start-up Hub Touring Car programs.

- Awards and recognition for SMEs and start-ups – best incubator & enterprise awards and best university business incubator awards.

- Strengthening Information Management Capabilities of SMEs – increase ICT adoption, provide e-learning program, e-commerce, promote 4G Mobile Commerce Application Service.

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