

Malaysian Science, Technology and Innovation Indicators Report 2016

MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION

Published By

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Frequency of publication: triennial

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ISSN 2550-1798



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PREFACE

This Malaysian Science, Technology and Innovation (STI) Indicators Report 2016 is the tenth volume in a series of STI indicators studies commissioned by the Malaysian Science and Technology Information Centre (MASTIC), Ministry of Science, Technology and Innovation (MOSTI). This report contains a collection of indicators sourced and compiled from various studies and surveys, which were commissioned by various ministries – as well as their units and agencies that are related to STI development in Malaysia. The report provides a wider overview of the status of STI and its progress.

MASTIC intends this report to be readily readable and comprehensible in order for the public to understand the STI progress of Malaysia. In addition, the report not only aids and benefits policymakers and management of STI related institutions in charting the future national STI development agenda; it also makes available the up-to-date STI data for researchers in the domain of STI studies. Specifically, the report aims to:

- i. Compile and provide information about Malaysia's STI indicators for the use of relevant stakeholders and policymakers – as well as fellow researchers, individuals and organisations in academia;
- ii. Comprehensively measure Malaysia's performance in the areas of STI, and evaluate the progress and outcome of various programmes implemented by the Government through the STI indicators;
- iii. Identify the potential areas for development to intensify the advancement of STI areas in Malaysia;
- iv. Benchmark internationally for comparison of Malaysia's performance in STI; and
- v. Present holistic suggestions and recommendations to policymakers for the advancement of STI areas in Malaysia.

As a whole, the report provides a holistic view of the STI progress of Malaysia.

ACKNOWLEDGEMENT

MASTIC would like to express its sincere appreciation to the top management of the Ministry of Science, Technology and Innovation (MOSTI) – and in particular, the Secretary-General – for their support and guidance in the preparation of the study report. MASTIC also extends its appreciation to the members of the Steering Committee and the Technical Committee for their feedback and insights, which were instrumental in improving the quality of the report.

The active participation of the stakeholders is much appreciated, namely ministries and agencies such as the Ministry of Higher Education; Ministry of International Trade and Industry; Ministry of Plantation Industries and Commodities; Economic Planning Unit; Examinations Syndicate; Malaysian Examinations Council; Academy of Sciences Malaysia; Energy Commission; Department of Statistics Malaysia; Malaysian Investment Development Authority; Malaysian Communications and Multimedia Commission; Intellectual Property Corporation of Malaysia; SME Corporation Malaysia; Inland Revenue Board; Central Bank of Malaysia; Malaysia Digital Economy Corporation; Federation of Malaysian Manufacturers; Institute for Medical Research; Malaysian Agricultural Research and Development Institute; National Space Agency; National Science Centre; and various divisions of MOSTI.

Special thanks go to those who have participated in providing the data – organisations, ministries, agencies and divisions – as well as the consultants and researchers from the University of Malaya Consultancy Unit.

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EXECUTIVE SUMMARY

Science, Technology and Innovation (STI) has emerged as one of the key drivers for national economic growth and social progress. In the quest to attain faster, sustainable and inclusive growth, public policy intervention has been widely used by governments around the world as a mechanism to stimulate the development of national STI capability and direct it towards priority areas of perceived national needs. As such, recording the status and progress in STI is essential. STI indicators report 2016 uses quantitative tools in grasping the progress of STI activities. More importantly, the importance of STI indicators has long been recognised – as early as the 1960s – by the Organisation for Economic Co-operation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organisation (UNESCO).

This report examines four important pillars of STI by utilising the concept of National Innovation System. The concept provides a systematic approach to better understand the STI ecosystem. **Pillar 1** – Human capital, public awareness and Information and Communication Technology (ICT) are considered as the enablers that serve as the foundation to promote and support STI development. Therefore, understanding the basic supporting environment for STI is vital; indeed, it empowers society to progress further in STI. **Pillar 2** – Public sector investment involves public investment by the government as well as the various Research and Development (R&D) programmes sponsored by the government over the years. **Pillar 3** – Industrial development in STI evaluates the innovation, knowledge and technological content of STI within the industrial sector. It entails firm level R&D, knowledge and innovation measurements. **Pillar 4** – STI scientific output captures the national scientific knowledge progress with regards to STI in Malaysia, specifically through the bibliometric and intellectual property indicators assessment. All the four pillars are interlinked to form and capture the National Innovation System. The main findings of the four main pillars are as follows:

Pillar 1: Supporting Environment for STI

- Human Capital Development: Secondary and Tertiary Education in S&T** – Generally, the performance of students in science and mathematics at the Sijil Pelajaran Malaysia (SPM) level has improved, in the sense of an increase in percentage of students scoring A and above for Mathematics and Science, over the period 2008 – 2013. The analysis also showed that the performance of males in the SPM is of concern, as the percentage of failure in Science and Mathematics is between two to three times higher than that of females. At the Sijil Tinggi Persekolahan Malaysia (STPM) level, the 2015 enrolment declined by 21% – 31% in Science and Mathematics subjects compared to 2013. Although the Science and Mathematics (STEM) enrolment is small (estimated to be less than 10% of the SPM STEM cohort), the performance has generally been relatively good (more than 47% scoring B- and above) and remained relatively consistent throughout the years. In contrast to the findings at the SPM level, males tend to score better (A- and above) in Mathematics (T) and pure science subjects at STPM. In Public Higher Learning Institutions, the number of enrolments for science courses has been consistently less than for non-science courses at the undergraduate levels – at a ratio of 45:55; while the doctoral level recorded a ratio of 50:50 for science against non-science since 2011. While there are more females at the undergraduate level, more males are observed at postgraduate levels. At the international level, Malaysia's performance in the OECD's Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) surveys has always been significantly below OECD and TIMSS global score averages. Since PISA focuses on evaluating the problem solving skills and knowledge of 15-year-old

students in the key areas, and TIMSS focuses on formal mathematical knowledge, these results should serve as an indicator that Malaysia must improve on the quality of learning and teaching in science and mathematics education.

- **Public Awareness of STI** – Malaysians are found to be either interested or very interested in the STI issues surveyed in 2014. They are most interested in the use of new inventions and technologies. Nevertheless, the number of Malaysians who are very interested in selected STI issues are far fewer in comparison to respondents from the United States of America (USA) and the European Union (EU). There is a concern that there has been declining interest in environmental pollution issues among Malaysians over the years 1998 – 2014. Also, over the past 16 years the average public knowledge of STI in Malaysia has been below 50%. Although Malaysian public knowledge on STI issues in 2014 improved compared to 2008, Malaysia is still behind developed countries such as the USA, the EU, South Korea and Japan. Malaysians generally have a positive attitude towards scientific research and STI. More than half of the Malaysian respondents perceive that scientific research brings greater benefits than harm, similar to those in the United Kingdom (UK) but fewer than those in the USA and the EU. Malaysians mostly perceived positive effects of STI on public healthcare, followed by working conditions and lifestyle. The 2014 survey found that more than one third of the Malaysian respondents are aware of STI related government programmes available, but their participation is relatively low at below 2.0%.
- **Information and Communication Technology** – Malaysia witnessed a sharp increase in broadband subscriptions during the period since the end of the 2000s. Wireless mode broadband is observed as the preferred mode of many subscribers in Malaysia since 2010. Regarding research, it is noteworthy that there was considerable funding during the period of the 10th Malaysia Plan for research, development and commercialisation activities. A substantial amount of the funding was allocated to ICT related research. In terms of ICT value added activities, it is noteworthy that there was an intensification of value added activities in 2010. It was then expanded further, attaining a value added capacity worth RM70.89 billion in 2015. The Multimedia Super Corridor (MSC) programme of Malaysia emerged as the catalyst of growth for the ICT industry in Malaysia. Malaysia – an emerging economy – gained its strength in two particular skill categories, namely “Software & Application Development” and “OS & Server Technologies”. Manufacturing stands out as the dominant industry that offers the most employment opportunities to the ICT labour market of Malaysia.

Pillar 2: Public Sector STI

- **R&D Investment and Research Workforce** – Malaysia’s Gross Expenditure on R&D (GERD) reached RM13.97 billion in 2014, which was the best performance since 2000. The R&D intensity – the percentage of GERD over Gross Domestic Product (GDP) – stood at 1.26% in 2014, a more than two-fold increase from the year 2000. About 73.45% of the R&D expenditure was classified as current expenditure. In terms of GERD by research type, Applied Research recorded three quarters of the overall R&D expenditure in Malaysia in 2014. Basic Research and Experimental Development Research account for 16.93% and 7.54% respectively. R&D activities in Malaysia were mainly public driven. The number of researchers has significantly increased since 2008 with the total R&D personnel at 114,539 persons, while the ratio of researchers to 10,000 workforce was 60.66 in 2014. Researchers with Master’s degrees surged about two-fold, from 32.62% in 2012 to 63.81% in 2014.

- Public Sector Investment in R&D: Major Grants and Programmes** – At the Pre-R&D stage, Cradle Funds supported a total of 134 Cradle Investment Programme (CIP) Catalyst projects (RM44.88 million), 7 U-CIP Catalyst projects (RM1.05 million) and 147 CIP 500 projects (RM72.19 million). R&D at the research stage was supported by ScienceFund from the Ministry of Science, Technology and Innovation (MOSTI) and several research grants from the Ministry of Higher Education (MOHE). A total of 1,489 ScienceFund projects valued at RM309.27 million were granted in 2011 – 2015, and S&T Core, Industry and Biotechnology clusters were the three main recipients of ScienceFund. As the major grant of MOHE, the Fundamental Research Grant Scheme (FRGS) has been approved for 6,874 projects with a total amount of RM631.80 million. TechnoFund and InnoFund provide funding to the development stage of R&D and Commercialisation. During 2011 – 2015, MOSTI granted 113 projects a combined amount totalling RM212.05 million under TechnoFund. More than half the approved TechnoFund projects were in the Industry cluster. For InnoFund, 83 projects were granted with a total combined allocation of RM23.21 million. In addition to public R&D grants, the Malaysian government has designed and implemented sector specific research programmes that aim to accelerate the development of STI capabilities of several strategic and emerging sectors in the country. These include – among others – biotechnology, nanotechnology, oceanography and Sea to Space (S2S). Also, the Malaysian Investment Development Authority (MIDA) continues to promote industry participation in undertaking R&D related activities. A total of 57 R&D projects under the various categories of incentives were approved in 2011 – 2015.

Pillar 3: Private Sector STI

- Innovation in Manufacturing and Services Sectors** – The National Survey of Innovation (NSI) 2015 indicates that the services sector seems to be more innovative than the manufacturing sector, with a higher percentage of innovative companies. The innovative companies in both sectors are mostly small, private limited companies or sole proprietorship. Few of the innovative companies are public limited companies. In addition, innovative companies in both sectors typically record annual sales of more than RM6 million. The main objective in performing innovation activities in both the manufacturing and services sectors is to improve product quality, followed by the aim of fulfilling regulations and standards. It is notable that in both sectors, a low degree of importance is placed on the objective of reducing environmental damage through innovation activities. The high innovation cost remains the most important factor hampering innovation activities in both sectors, followed by the knowledge factor. Internationally, Malaysia is among the top 20 most competitive economies globally, ranking 18th in the Global Competitiveness Index (GCI) 2015 – 2016. Switzerland is ranked 1st, followed by Singapore. In the Global Innovation Index (GII) 2016, Malaysia is ranked 35th, higher in ranking than Thailand (52nd) and Indonesia (88th) but lower than Singapore (6th). In the Southeast Asia & Oceania region group, Malaysia at 8th place is one position below China at 7th. Globally, Malaysia is ranked 59th in terms of innovation efficiency ratio.
- Knowledge and Technology Intensive Industries** – The Knowledge Intensive (KI) sector's value added in Malaysia recorded an increase from USD11,782 million to USD38,154 million from 2000 to 2014. The financial and business services are the among top KI services which registered the highest value added output. Health and social services, education services and business services recorded a significant annual average value added growth of 37.39%, 32.21% and 23.75% respectively between 2010 and 2014. Whereas in High-Technology (HT) industries, the semiconductor and computer and office machinery industries contributed the highest in terms of value added and exports. The testing, measuring, and control instruments, pharmaceutical

and aircraft and spacecraft, sectors recorded an impressive annual average export growth of 30.52%, 24.68% and 15.17% respectively over the 2000 – 2014 period. These industries can be new potential growth industries for Malaysia. Both HT and KI services industries are playing a crucial role in enhancing national economies. Nevertheless, Malaysia's Knowledge and Technology Intensive Industry (KTI) value added is lower (USD 63,154 million; GDP share of 19%) in contrast to other Asian economies such as the Philippines, Thailand and Singapore. Specifically, in 2014, Malaysia's KI industry value added output was lagging behind compared to other Association of Southeast Asian Nations (ASEAN) nations like Indonesia, the Philippines, Thailand and Singapore. Ultimately, Malaysia is losing its long-term competitiveness to other ASEAN countries, mainly in the KI services segment. It is noteworthy that from 2004 to 2013, Malaysia is documented to have had a consistent trade deficit in commercial knowledge intensive services compared to other ASEAN nations like Singapore and the Philippines.

- ***Energy and Green Technology*** – Malaysia has shown gradual progress in green technology diffusion due to various incentives and programmes. Indeed, Malaysia was able to reduce its carbon footprint. Nevertheless, the source of energy in Malaysia is still predominantly fossil fuel, namely coal and natural gas. Challenges remain in diffusing renewable technologies – given the lower cost of fossil fuels, high cost of renewable technologies, high investment requirements and limited technological know-how. The planned net metering and other initiatives such as green vehicles, green buildings and others are expected to improve Malaysia's STI agenda in Renewable Energy (RE), especially with regards to STI in green technology and R&D. More effort is needed to decouple growth from conventional sources of energy – especially fossil fuel – and link growth instead to green energy, in order to drive the green economy.

Pillar 4: STI Outputs

- ***Bibliometrics: Publications and Citations*** – Malaysia witnessed a trend with a consistent increase in publications. It had the capacity of producing 10,499 articles in 2014. The increase of publications is in tandem with the increase of citations. "Materials Science", comprising publications reporting multidisciplinary research findings, emerged as the top field. This study also observed that Malaysia's scientists are keen to work with those abroad for joint publications. Universiti Malaya (UM) emerged as the top institution in performing scientific publication, with the capacity to produce 14,920 articles over a period of 13 years.
- ***Intellectual Property Rights*** – Malaysia's patent and utility innovation applications trend in Intellectual Property Corporation of Malaysia (MyIPO) manifested an increasing capacity, from 1,136 patents in 2011 to 1,375 in 2015. The foreign applications of patents are far ahead compared to those of Malaysia. MIMOS Berhad and Universiti Teknologi Malaysia (UTM) stand out as the most productive organisations in Patent Cooperation Treaty (PCT) patenting activities. Information and communication technology emerged as the dominant field in Malaysia's patent application landscape. For trademarks, the applications more than doubled in 2015 compared to 2001, while registration increased fourfold. The share between foreign and Malaysian applicants seems to be relatively equal. For industrial design, Malaysia witnessed a considerably high number of applications in 2012 and 2013.
- ***Commercialisation and Returns on R&D*** – There has been gradual progress in commercialisation activities in Malaysia. During the 9th Malaysia Plan, 8% of the publicly funded R&D projects were commercialised. Despite also being low, the private sector's commercialisation of Intellectual Property Rights (IPRs) is still much

higher than the public sector. The application and approval of IPRs remains high, however the translation of these IPRs into revenue streams remained low. There is a trade deficit of royalties and licensing fees. Selected institutions and programmes such as the Malaysian Palm Oil Board (MPOB) and the Commercialisation of R&D Fund (CRDF) show significant success in commercialisation. Fields such as medical and health, ICT and agriculture show higher commercialisation than other fields.

The report further identifies the potential areas in which Malaysia has progressed well and areas needing improvement. General recommendations are provided in areas that require further improvements. These recommendations are based on the analysis of the trends of indicators – which is general in nature – and more detailed investigations and engagement with various stakeholders are needed to further assess the recommendations for future policy direction.

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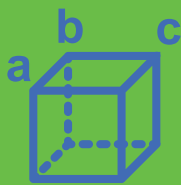


Introduction



Public Sector STI

- R&D Investment and Research Workforce
- Public Sector R&D Investment - Major Grants and Programmes



Supporting Environment for STI

- Human Capital Development: Secondary and Tertiary Education in S&T
- Public Awareness of STI
- Information and Communication Technology

1 Pillar

2 Pillar



▶▶ CHAPTER 1

Private Sector STI

- Innovation in Manufacturing and Services Sectors
- Knowledge and Technology Intensive Industries
- Energy and Green Technology



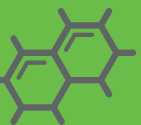
National STI Outputs

- Bibliometrics: Publications and Citations
- Intellectual Property Rights
- Commercialisation and Returns on R&D Investment



3 Pillar

4 Pillar



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CHAPTER 1: INTRODUCTION

1.1 Introduction

Science, Technology and Innovation (STI) has emerged as one of the key drivers for national economic growth and social progress. In the quest to attain faster, sustainable and inclusive growth, public policy intervention has been widely used by governments around the world as a mechanism to stimulate the development of national STI capabilities, directed towards priority areas of perceived national needs. However, national investments in STI need to be thoroughly and strategically managed – given the inherent uncertainty, costliness and risk associated with STI investments. The effectiveness and efficiency of public investment in stimulating STI development needs constant evaluation in order to determine the benefits from these investments. In this regard, the ability to measure the STI progress and achievements of a nation is important. The growing concern about public accountability of government funded STI programmes and institutions has also resulted in a demand for national STI indicators. This explains why STI indicators – a quantitative statistical tool in grasping the progress of STI activities – have today become essential in evaluating STI activities. Moreover, the importance of STI indicators has long been recognised (as early as the 1960s) by the Organisation for Economic Co-operation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organisation (UNESCO). Due to the complex nature of STI systems, the availability of up-to-date data on the various dimensions and stages of STI activities is vital in order to inform policymakers – both on national achievements in STI, and in comparison to other countries. As a whole, national STI indicators are useful for the purpose of monitoring and benchmarking and for foresight of STI activities, as well as for “Science of Innovation Policy”.

Since 1992, the Malaysian Science and Technology Information Centre (MASTIC) has carried out studies on national STI indicators for systemically ascertaining the STI performance in Malaysia. The Malaysian Science, Technology and Innovation Indicators Report 2016 will be the tenth volume in the series of STI indicators reports published by MASTIC. To maintain consistency with the previous STI indicators reports, as well as for the purpose of international comparison, this report will closely follow the guidelines provided by the Science and Engineering Indicators – that is, the National Science Foundation (NSF) and the OECD Science and Technology Indicators. The National Innovation System framework, which is currently at the centre of STI studies, is also used as the analytical framework for this report – both in the process of determining the dimensions of STI indicators, as well as in suggesting evidence-based policy recommendations.

The collection and dissemination of STI data in the country ranges from centralised to widely dispersed institutions. Thus, the STI data for this report is sourced and compiled from numerous studies and surveys commissioned by the various ministries, as well as their units and agencies that are related to STI development in Malaysia. Since STI activities are technical-socio-economic hybrids, this report adopts a wide spectrum of key indicators that covers various STI activities – ranging from science and engineering indicators to socio-economic indicators. Indeed, this approach serves to determine the impacts of STI investments on the wider social and economic systems of the country; and conversely, the relationship between the socio-economic systems and STI systems of the country.

Malaysia is ranked 18th in the overall world competitiveness ranking, 47th in technological readiness, and 17th in innovation and sophisticated factors (World Economic Forum, 2015). The current Malaysian performance has improved compared to 2013 – where Malaysia was only ranked 25th in overall competitiveness ranking, 51st in technological readiness, and 23rd in innovation and sophisticated factors. Also, Malaysia is placed 35th in the overall Global Innovative Index (GII) ranking, 2nd among the upper-middle-incomes economies, and 8th in the SouthEast Asia and Oceania region. Despite these achievements, Malaysia has yet to reach the innovation-driven nation stage. The efficiencies of the innovation inputs and outputs have been the main shortcomings restricting Malaysia from moving higher up in the GII ranking. Hence, there should be greater efforts made to improve the institutional support, private participation in R&D, and knowledge-based activities in order to turn Malaysia into an innovative nation.

Hence, the compilation of comprehensive STI indicators in this report is timely and necessary in order to assess and ascertain the latest status of STI development in Malaysia. This report is one of the efforts by the Ministry of Science, Technology and Innovation (MOSTI) to periodically take stock of the investments and outcomes of STI activities. The findings of this report will benefit not only the policymakers and the management of STI-related institutions in charting the future national STI development agenda; it will also supply available up-to-date STI data for researchers.

1.2 Objectives of the Study

The main objectives of the Malaysian Science, Technology and Innovation (STI) Indicators Report 2016 are to:

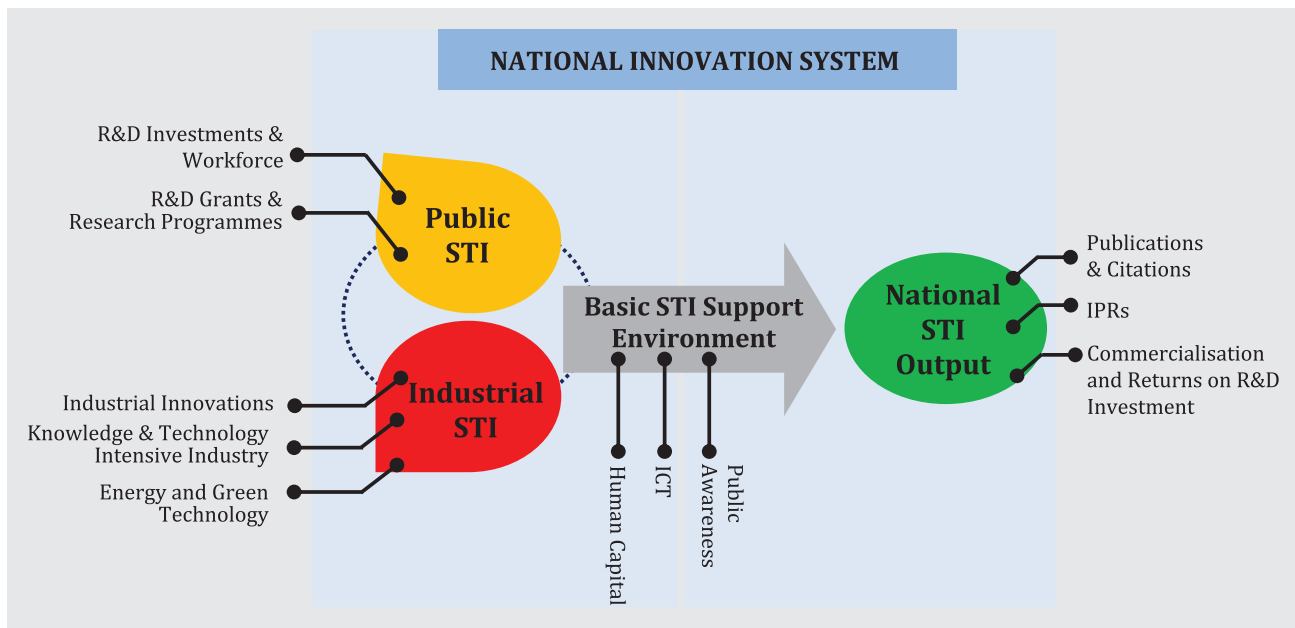
- i. Compile and provide information about Malaysia's STI indicators for the use of relevant stakeholders and policymakers – as well as fellow researchers, individuals and organisations in academia;
- ii. Comprehensively measure Malaysia's performance in the areas of STI, and evaluate the progress and outcome of various programmes implemented by the government through the STI indicators;
- iii. Identify the potential areas for development to intensify the advancement of STI areas in Malaysia;
- iv. Benchmark internationally for comparison of Malaysia's performance in STI; and
- v. Present holistic suggestions and recommendations to the policymakers for the advancement of the STI areas in Malaysia.

1.3 Methodology, Framework and Scope of Study

The methodology adopted for this study follows that of the OECD¹, as well as the Science & Engineering Indicators by the National Science Foundation, United States. Common indicators that reflect the investment in STI and the STI environment were used. Since the report compiles indicators from other reports, the definition of indicators follows the standard definitions provided by the respective reports. In addition, this report also reflects the Malaysian scenario and the context by which new indicators are explored based on the R&D related programmes established in Malaysia. The concept of National Innovation System was utilised to form the framework of the study. The concept provides a systematic approach to better understand the STI ecosystem.

Figure 1.1 shows the framework of the study that focuses on four main pillars of STI. **Pillar 1** assesses the basic STI support environment. Human capital, Information, Communication and Technology (ICT), and public awareness are considered as the enablers that serve as the foundation to promote and support STI development. Therefore, understanding the basic supporting environment for STI is vital. Indeed, it empowers society to progress further in STI. **Pillar 2** assesses the public investments that involve the government, as well as the various research and development (R&D) programmes sponsored by the government over the years. **Pillar 3** assesses the industrial STI development – evaluating the innovation, knowledge and technological content of STI within the industrial sectors. It entails firm level R&D, knowledge and innovation measurements. **Pillar 4** assesses the scientific outputs, namely capturing the national scientific knowledge progress with regards to STI in Malaysia – specifically, through the bibliometric and intellectual property rights (IPRs) indicators assessment. In addition, commercialisation outcomes are captured. All the four pillars are interlinked to form and capture the National Innovation System.

Figure 1.1 Assessment of STI Indicators



Source : University of Malaya Consultancy Unit

¹ The OECD has developed a series of technical guidelines on the measurement of various STI activities, with a view to promoting the international comparability of data. The study uses some of these indicators, while others follow the standard adopted by Malaysia in various reports.

The framework provides policymakers with a better understanding of the status of STI and the current position of the STI ecosystem in four areas, namely: enablers of STI; public sector STI; private sector STI; and national STI outputs regarding publications, intellectual property and income.

As a whole, measuring the STI indicators assists in:

- Formulating the national innovation strategies, including designing and implementing STI policies;
- Developing a systemic approach to understanding the progress of the National Innovation System;
- Comparing STI indicators at the international, national and regional levels to fulfil the need for international and national assessment; and
- Improving the STI linkages within the STI ecosystem that enables the achievement of development goals.

The scope of the report considers the input and output related assessment of the STI indicators. It highlights long-term trends and characteristics of STI activities with regards to investments and outputs. It addresses questions such as: *What is the scientific landscape of Malaysia like today, in comparison with other nations? How much has the supporting environment progressed in Malaysia? What are the government's commitments towards STI? How have the firms progressed in R&D, innovation, knowledge and technological content? What is Malaysia's position in STI?* Apart from the quantitative assessment, qualitative information is collected to complement the indicators through secondary sources, e.g. reports, policy documents and other sources. The time periods in capturing the indicators vary based on data availability.

1.4 Caveats of the Study

The findings of the present report are subject to the following limitations.

- Data for this report are drawn from various currently available sources. Data limitations may exist. The selection of indicators is limited based on data availability.
- Time periods covered in the report depend on data availability. In most cases, the data is extended from the preceding S&T indicators study to include the most recent years in this report. Nevertheless, when there is any data discontinuation, the indicators are excluded.
- In some cases, a relevant proxy is used to capture the STI activities when available. Some of these indicators may not be able to truly capture or represent STI activities. Therefore, caution should be exercised in making generalisations if proxies are used to understand the development of the STI activities in Malaysia.
- Since various reports of MOSTI and published findings from various agencies are used as inputs, the methodology and indicator definitions follow the respective reports.

1.5 Summary

This report provides an overview of the STI progress in Malaysia by evaluating the key inputs and outputs within the four main pillars, namely: supporting infrastructure for STI; public sector investments in STI; industrial sectors in STI; and the knowledge and technological outcome of STI. It provides a more holistic understanding of the state of STI performance in Malaysia.



Human Capital Development: Secondary and Tertiary Education in Science and Technology

SPM

ICT

ICT enrolment increases, (2008 – 2014), relative to other technical subjects.

A

An increasing trend in A (and above) achievers in Mathematics and Science for 2008 – 2013.



Percentage of failures in Science and Mathematics among males are between two to three times higher than females.

STPM



A declining trend in 2015 enrolment by 21% – 28% in Mathematics (T), Physics, Chemistry, Biology and ICT, compared to 2013; likewise, Mathematics (M) declined by 31%.



S&T EXAMINATIONS SCORE



HLI : Public Universities (2008 – 2015)

Undergraduate Degree Level (female graduates more)

Science Non-Science

45 : 55

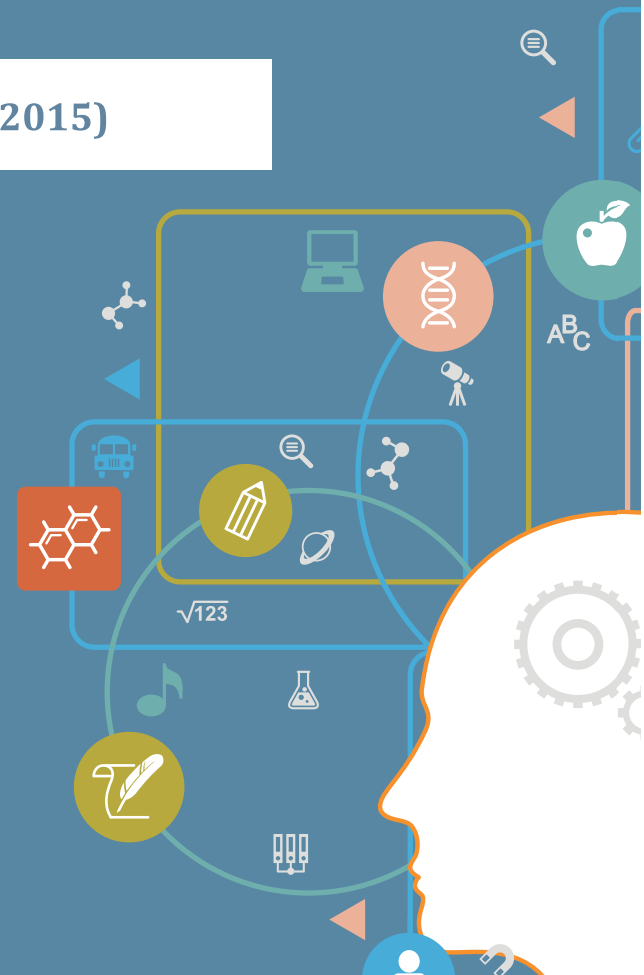
Doctoral Level (male graduates more)

Science Non-Science

50 : 50

Enrolment in Public HLI, First Degree (2008 – 2015):

Engineering & Engineering Trades, Computing, Physical Sciences and Health jointly contribute to an average of 70% – 72% of all STEM enrolment annually.

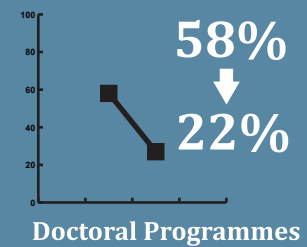
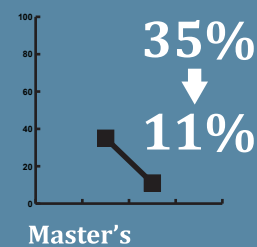
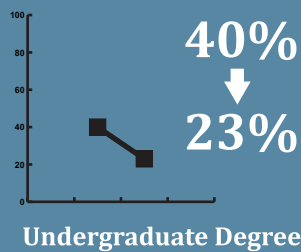


▶▶ CHAPTER 2



HLI: Private Universities (2008 - 2015)

Stem Enrolment



TVET

At MTUN, Engineering & Engineering Trades Enrolment (2008-2015):

75% - 83%
Diploma Level

75% - 86%
Undergraduate
Degree Level

At Non-MTUN, Engineering & Engineering Trades, ICT, Architecture & Building, and Agriculture, Forestry & Fishery jointly contribute more than 80% of all STEM enrolment



International Comparison

Malaysia's performance in OECD PISA and TIMSS survey has always been below the OECD and TIMSS global average scores — an indicator that Malaysia must improve on the quality of learning and teaching in Science and Mathematics education.





CHAPTER 2: HUMAN CAPITAL DEVELOPMENT: SECONDARY AND TERTIARY EDUCATION IN SCIENCE AND TECHNOLOGY

2.1 Introduction

The commitment of Malaysia to harnessing Science, Technology and Innovation (STI) as a key driver in raising the national capacity to acquire and utilise knowledge – as well as fostering innovation – is reflected by the formulation and implementation of various initiatives and programmes, including the STI policies: National Science and Technology Policy 1 (NSTP1) 1986 – 1989; National Science and Technology Policy 2 (NSTP2) 2002 – 2010; and Industrial Technology Development: A National Plan of Action (1990 – 2001).

In developing and nurturing talent in STI, Malaysia is committed to ensuring the quality and effectiveness of Science, Technology, Engineering and Mathematics (STEM)²; The Malaysia Education Blueprint 2013 – 2025 further affirms the critical role of STEM education in turning Malaysia into a knowledge-based economy. This is through providing equal access to quality education of an international standard; strengthening the quality of Science, Technology, Engineering and Mathematics (STEM) education through revised curriculum, implementation and monitoring to address gaps in knowledge and skills among students; and exploring the use of blended-learning models that leverage technology to enhance student learning.

This chapter discusses the STEM education in Malaysia from upper secondary school to the university level. The data presented in this chapter have been obtained from four main sources, namely: the Ministry of Higher Education (MOHE); the Ministry of Education (MOE); the Examinations Syndicate (ES); and the Malaysian Examinations Council (MEC). The data obtained are from both public and private institutions, to allow comparisons of student enrolments and graduations at various levels of the higher education system.

2.2 Education in Science, Mathematics and Technology at SPM, STPM Levels and Pre-University Foundation Programmes

The Sijil Pelajaran Malaysia (SPM), or the Malaysian Certificate of Education, is a national examination taken by all fifth-year secondary school students in Malaysia, an equivalent to the O-level in the United Kingdom (UK) and the eleventh grade in America's K-12 (education). Set and examined by the Examinations Syndicate (*Lembaga Peperiksaan*), this is the second last public examination at the secondary school level before entry into tertiary level education at a university or other higher education institution. The Sijil Tinggi Persekolahan Malaysia (STPM) and Matriculation / Pre-University programmes are the equivalent of the GCE A-Level in the UK. While the STPM is set and examined by the Malaysian Examinations Council (*Majlis Peperiksaan Malaysia*), the examinations for Matriculation are conducted by the Matriculation Division, Ministry of Education. Pre-University foundation programmes at public institutions are offered at 17 matriculation centres and 10 public universities. While Science, Technical and Accounting programmes are offered at the matriculation centres, there are more specific programmes that are offered under the foundation programmes at

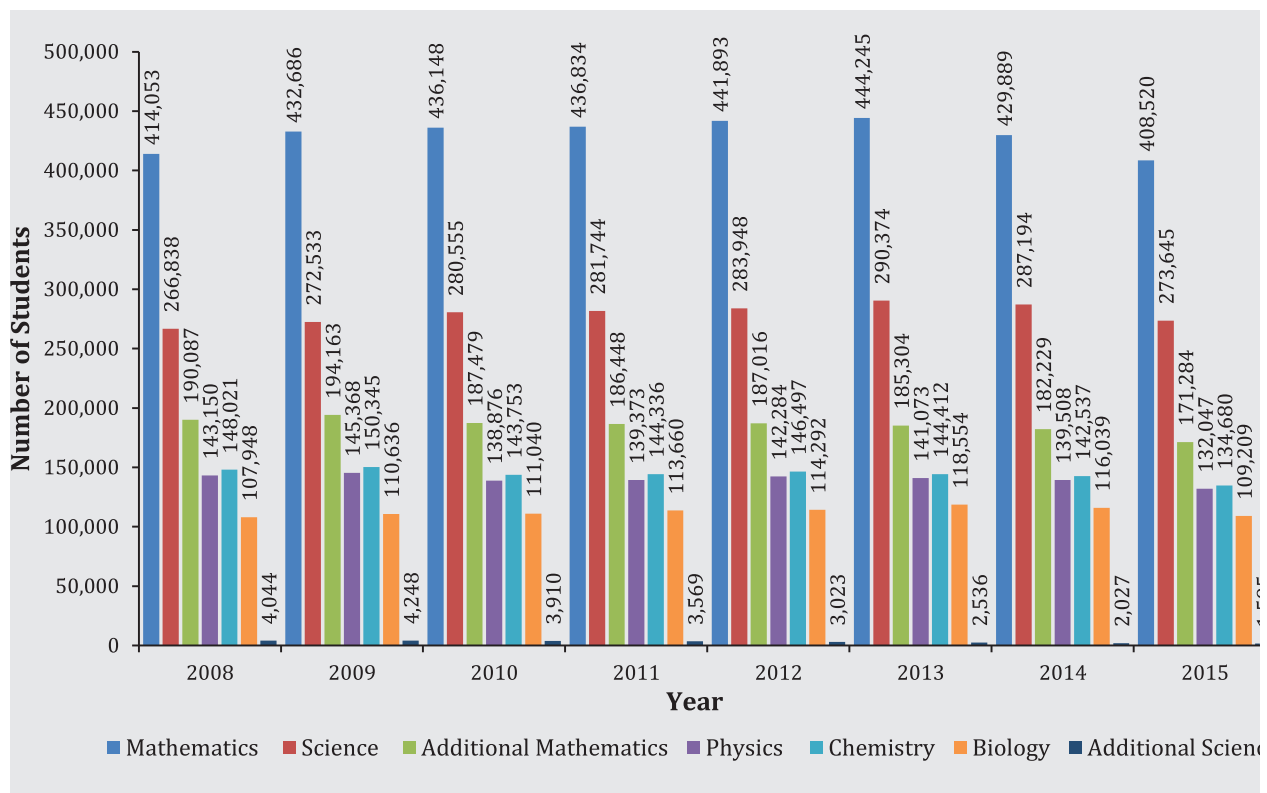
² STEM refers to the subjects based on the National Education Code (NEC). Refer to Appendix 1.

some public universities; this includes foundation programmes in medicine and dentistry. This section discusses the trends of science, mathematics and technology education, in terms of student enrolments and grades attained at the SPM, STPM, Matriculation (Pre-University) levels.

2.2.1 Science, Mathematics and Technical Subjects at SPM Level

Mathematics (code 1449) is a compulsory subject for all SPM students. For pure science stream, students have these electives: Additional Mathematics, Physics, Chemistry, Biology, Additional Science, and Information and Computer Technology. Science (code 1511) is compulsory for students in the Commerce, Literature and Arts streams only. Figure 2.1 displays the number of registered students³ by subject from 2008 – 2015. Throughout this period, the number of students registered for Additional Mathematics, Physics, Chemistry and Biology subjects is relatively constant, even though the total number of registered students for Mathematics decreased slightly in 2014 and 2015.

Figure 2.1 Registration for Science and Mathematics at SPM, 2008 – 2015



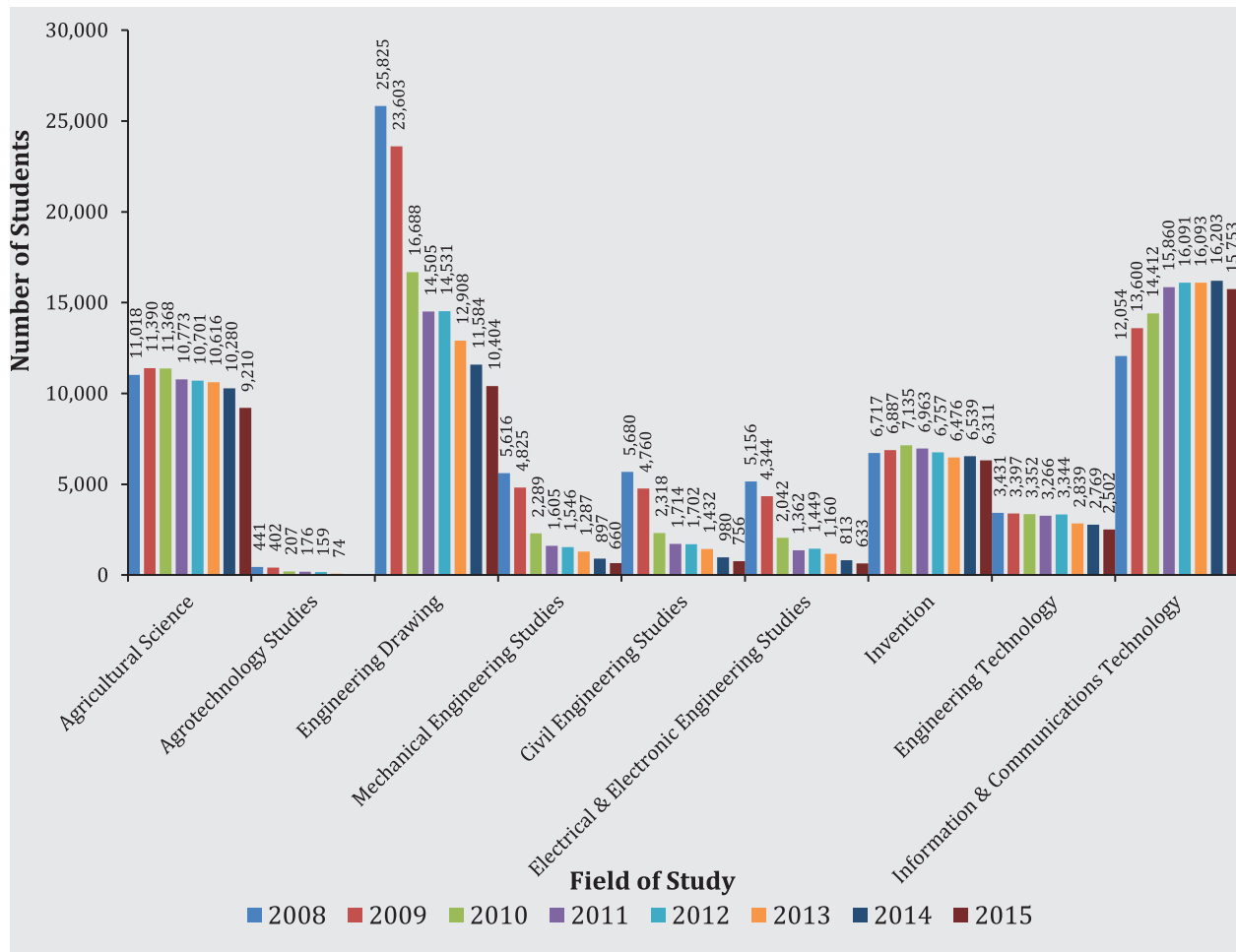
Source : Examinations Syndicate

Figure 2.2 shows the number of students registered for technical subjects at the SPM level for 2008 – 2015. Over the years, the number of students registered for ICT increased; however, the same cannot be said for engineering related subjects, especially engineering drawing. The

³ The data comprises: (i) all school candidates excluding private candidates; and (ii) new candidates/first timers sitting for SPM.

change in trend towards ICT could be due to the Government’s emphasis on ICT over the years, which lends support to the success of the implementation. The number of registrations for Engineering Technology, Invention and Agriculture are relatively constant, while Mechanical Engineering, Civil Engineering and Electric & Electronic Engineering Studies have observed a significant drop over the years.

Figure 2.2 Registration for Technical Subjects at SPM, 2008 – 2015

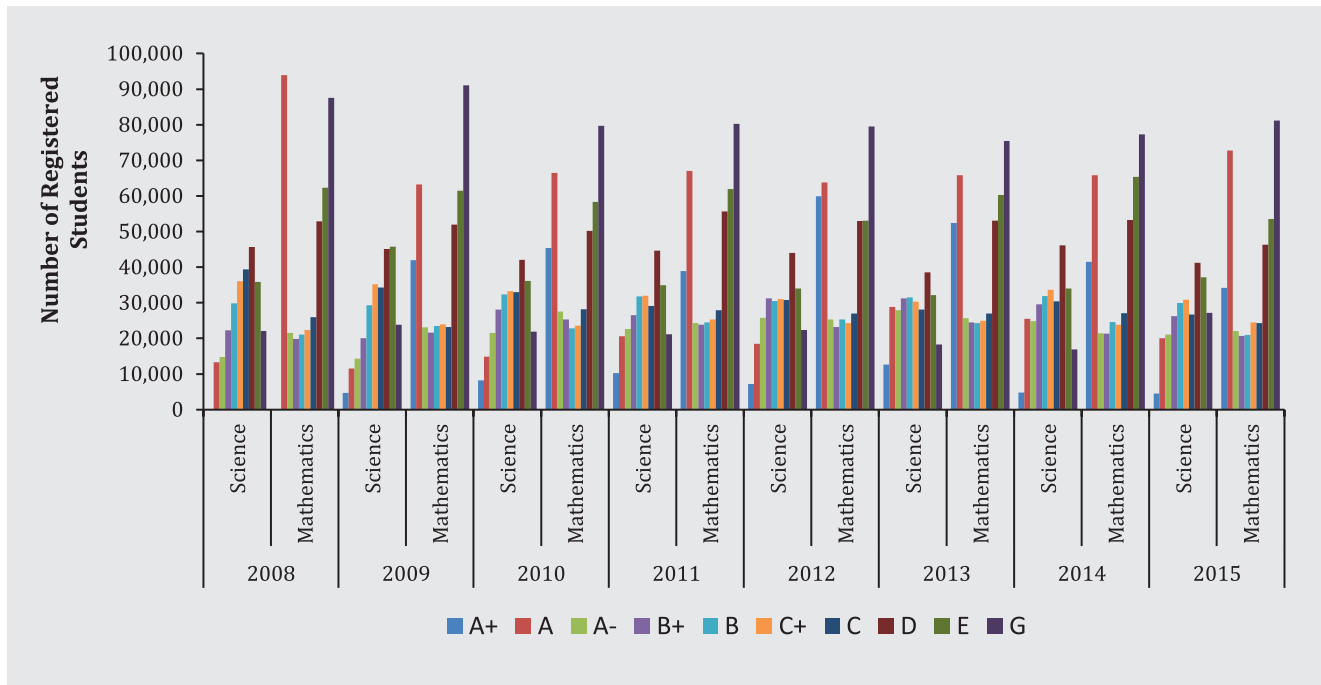


Source : Examinations Syndicate

I. Examination Grades for Science and Mathematics at SPM Level

An increasing trend is observed over the years 2008 – 2013 in the total number of A and A+ achievers (and their equivalents) for Mathematics and Science, as illustrated in Figure 2.3. The percentage of students with grade G (failed) in Science declined from 9% in 2008 to 6% in 2014, while the percentage of students with grade G in Mathematics stood around 18% for 2010 – 2014. However, these percentages increased to 10% and 20% respectively in 2015.

Figure 2.3 Grades Attained for Mathematics and Science at SPM, 2008 - 2015



Source : Examinations Syndicate

II. Examination Grades for Science and Mathematics at SPM Level by Gender

Table 2.1 and Table 2.2 show that females perform better than males both in Mathematics and Science at the SPM level. The percentage of females scoring A- and above for Science is approximately twice that of males. In terms of failures (grade G) in the subject, the percentage of failures among males is approximately three times that of females. The trend is similar for Mathematics, with a lesser gap among the groups (for A- and above, as well as for grade G). The low scores among males must be addressed in order to bring them to the same level as their female counterparts.

Table 2.1 Examination Grades for 1511-Science at SPM, by Gender (%)

Year	2008		2009		2010		2011		2012		2013		2014		2015	
Grade	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
A+	-	-	1.2	2.4	2.1	4.1	2.5	5.2	1.9	3.4	3.2	6.3	1.2	2.3	1.1	2.4
A	3.9	6.5	3.0	5.8	3.8	7.5	5.3	10.3	5.0	8.8	7.7	13.9	6.7	12.0	5.5	10.0
A-	4.4	7.0	3.9	7.1	5.8	10.6	6.2	11.0	7.3	12.0	8.1	12.8	6.9	11.3	6.0	10.2
B+	6.9	10.3	5.6	9.8	8.0	13.3	7.9	12.2	9.3	14.0	9.7	13.8	8.8	13.0	7.8	12.4
B	9.8	13.3	8.9	13.7	10.2	14.4	10.4	13.7	9.9	12.9	10.3	13.3	10.3	13.2	9.8	13.3
C+	12.4	15.4	11.7	15.4	11.6	13.7	11.4	12.9	11.0	12.2	10.8	12.0	11.6	13.1	10.9	12.8
C	14.8	15.5	12.6	13.8	12.8	12.3	11.2	10.9	11.8	11.2	10.7	10.3	11.5	10.8	10.2	10.3
D	19.3	15.9	18.7	16.1	18.4	13.6	19.3	14.6	18.4	14.4	16.6	12.3	19.1	14.6	17.2	14.4
E	16.7	10.9	21.6	13.8	17.5	9.9	16.6	9.9	15.5	9.9	15.7	8.4	15.8	9.0	17.4	11.0
G	11.8	5.2	14.0	4.5	12.0	4.6	11.7	4.4	11.8	4.9	10.4	3.2	9.3	3.0	15.2	5.6

Source : Examinations Syndicate

Table 2.2 Examination Grades for 1449-Mathematics at SPM, by Gender (%)

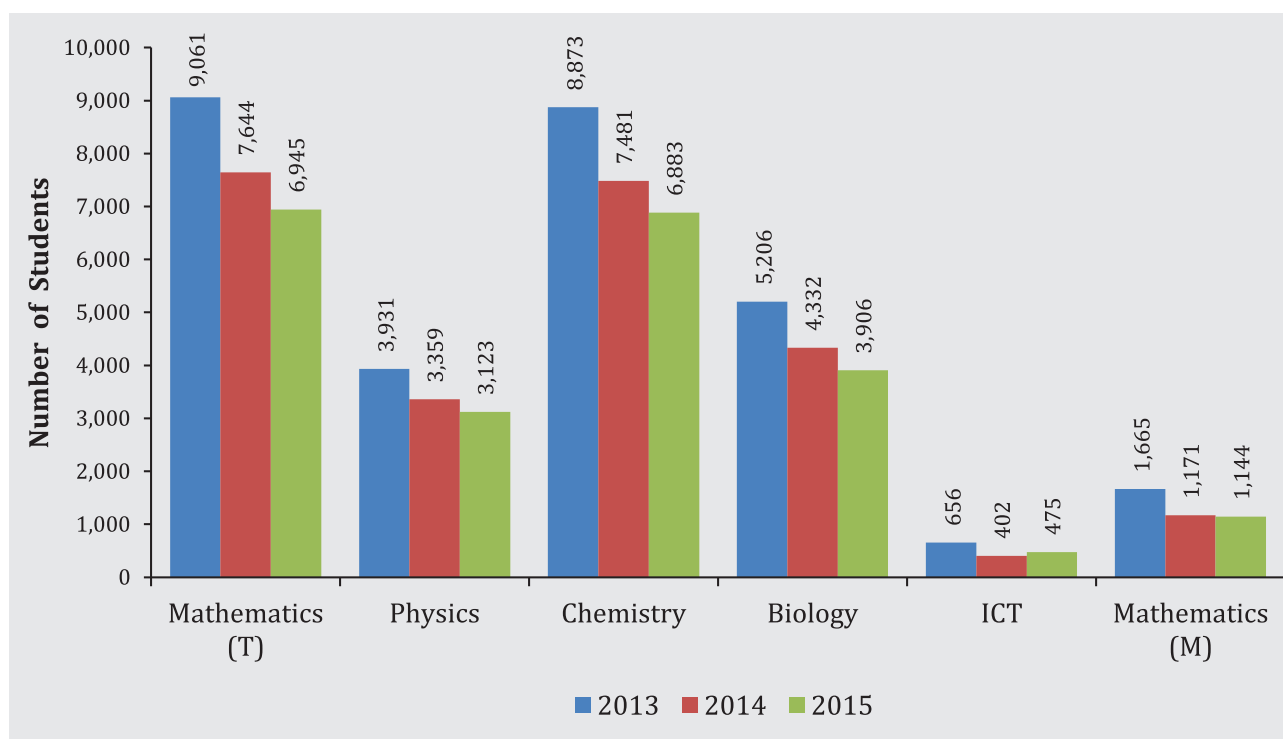
Year	2008		2009		2010		2011		2012		2013		2014		2015	
Grade	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
A+	-	-	9.9	11.9	10.9	12.8	9.0	10.9	13.8	18.1	12.3	15.1	9.8	12.0	8.4	10.2
A	20.4	25.6	13.8	19.1	14.4	20.3	14.5	19.6	14.3	19.7	14.4	20.0	14.8	19.7	16.8	22.7
A-	4.4	6.1	5.0	7.0	6.1	8.3	5.3	7.1	5.6	7.9	5.5	7.9	4.6	6.6	5.0	7.0
B+	4.1	5.6	4.8	6.4	5.7	7.6	5.2	6.9	5.2	7.2	5.3	7.5	4.6	6.5	4.5	6.7
B	4.6	5.7	5.4	6.8	5.2	6.7	5.5	7.0	5.8	7.7	5.4	7.3	5.3	7.5	4.7	6.7
C+	4.9	6.0	5.6	6.8	5.5	6.8	5.9	7.1	5.7	7.2	5.7	7.3	5.3	7.2	5.6	7.6
C	5.9	6.8	5.5	6.6	6.6	8.1	6.5	7.8	6.5	7.9	6.3	7.8	6.4	7.7	5.9	7.3
D	12.5	13.5	12.9	14.2	12.5	13.8	13.5	14.9	13.5	14.8	13.1	14.7	13.3	14.6	11.8	13.4
E	15.5	15.1	16.4	15.7	16.3	14.3	16.4	15.3	14.9	13.5	16.8	14.9	17.8	16.7	15.5	13.8
G	27.7	15.6	30.4	17.3	27.8	14.2	27.2	14.2	28.5	14.2	27.3	12.7	27.7	13.5	30.2	14.7

Source : Examinations Syndicate

2.2.2 Science, Mathematics and Technical Subjects at STPM Level

At the STPM level, Mathematics (T) recorded the highest number of students registered⁴ from 2013 – 2015, followed by Chemistry, Biology and Physics, as displayed in Figure 2.4. Information and Communications Technology (ICT) and Mathematics (M) received very low numbers of registered students, and declined by 28% and 31% respectively over the years 2013 to 2015. In general, the number of registrations for all subjects are decreasing over the years, in tandem with the decrease in student enrolments in recent years.

Figure 2.4 Registration for Science and Mathematics at STPM, 2013 – 2015

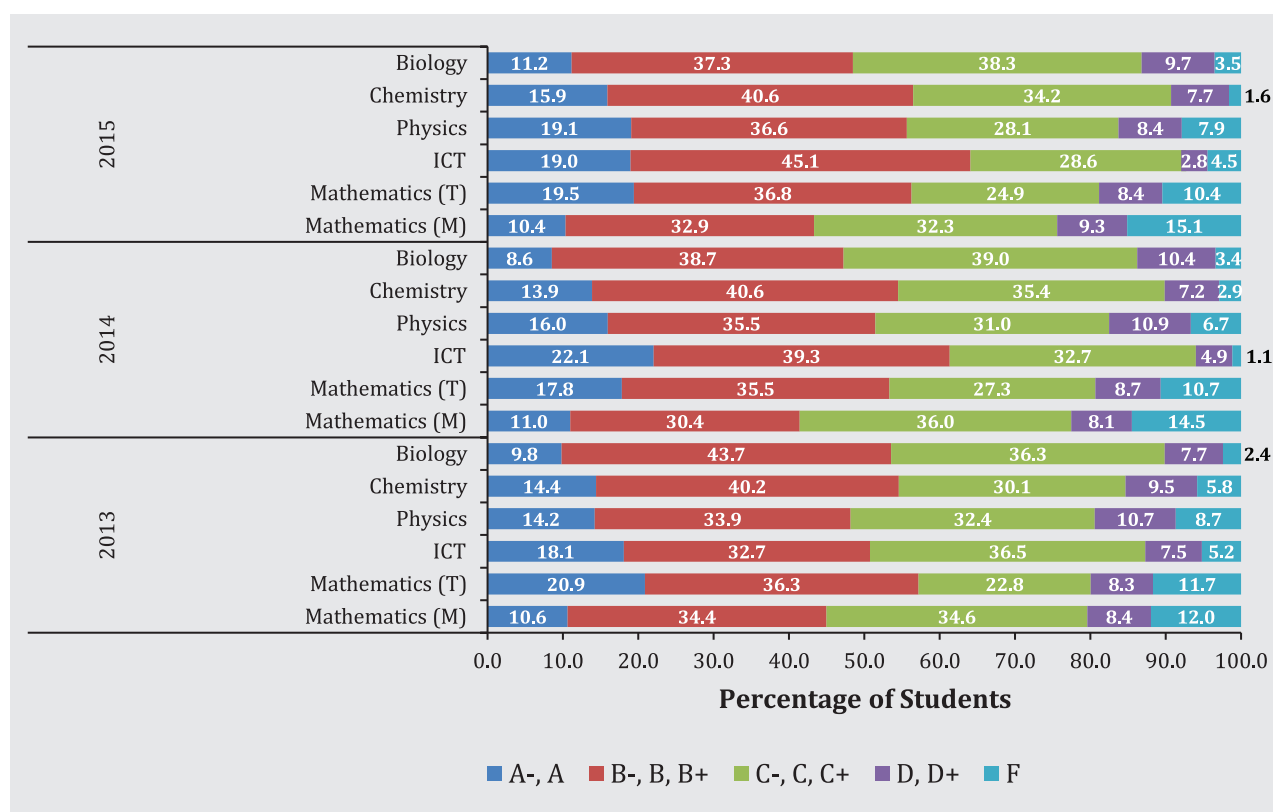


Note : Mathematics (T) is related to Science and Technology; Mathematics (M) is related to Social Science and Management.
 Source : Malaysian Examinations Council

I. Examination Grades for Science and Mathematics at STPM Level

Figure 2.5 displays the percentages of students with the respective grades scored at the STPM examination, 2013 – 2015. There are more students scoring A- and above in Mathematics (T) and ICT. Over the years, Physics recorded an increasing trend towards A (A- and above), while Chemistry has improved with a reduced percentage of F, from 5.8% in 2013 to 1.6% in 2015.

⁴ The new STPM examination i.e. the modular system was introduced in 2013. Under this system which is made up of three terms, examinations are administrated three times (once at the end of each term). Prior to this, the terminal system was used where examinations were conducted once at the end of the Upper Sixth Form.

Figure 2.5 Examination Grades for Science and Mathematics at STPM (%)

Source : Malaysian Examinations Council

II. Examination Grades for Science and Mathematics at STPM Level by Gender

It is interesting to note that there are more males studying Physics (an average of 64%) relative to females, and more females studying Biology (an average of 73%) relative to males (Table 2.3). In terms of percentages of scores, males tend to score better (A- and above) relative to females in Mathematics (T), ICT, Physics, Chemistry and Biology. In terms of grade F, the gaps between male-female in ICT and Chemistry are marginal relative to Physics, Mathematics (T) and Biology. For Mathematics (M), females tend to do better, with good scores (A- and above) and a small percentage of F compared to males.

2.2.3 Science, Mathematics and Technical Subjects at Matriculation Programmes

The Malaysian Matriculation Programme is a one- or two-year pre-university preparatory programme offered by the Ministry of Education, Malaysia. The programmes offered are Science (under a one- or two-year programme), Technical Programme and Accounting Programme. The Science programme comprises Mathematics and Chemistry as compulsory subjects, and another two chosen from either Physics, Biology or Informatics. The Accounting programme is made up of Mathematics, Accounting, Business Study and Economy; while the Technical Programme comprises of four subjects, namely, Mathematics, Chemical Engineering, Physical Engineering and Engineering Study. The Technical Programme was first introduced in the academic session of 2009/2010.

Table 2.3 Examination Grades for Science at STPM, by Gender (%)

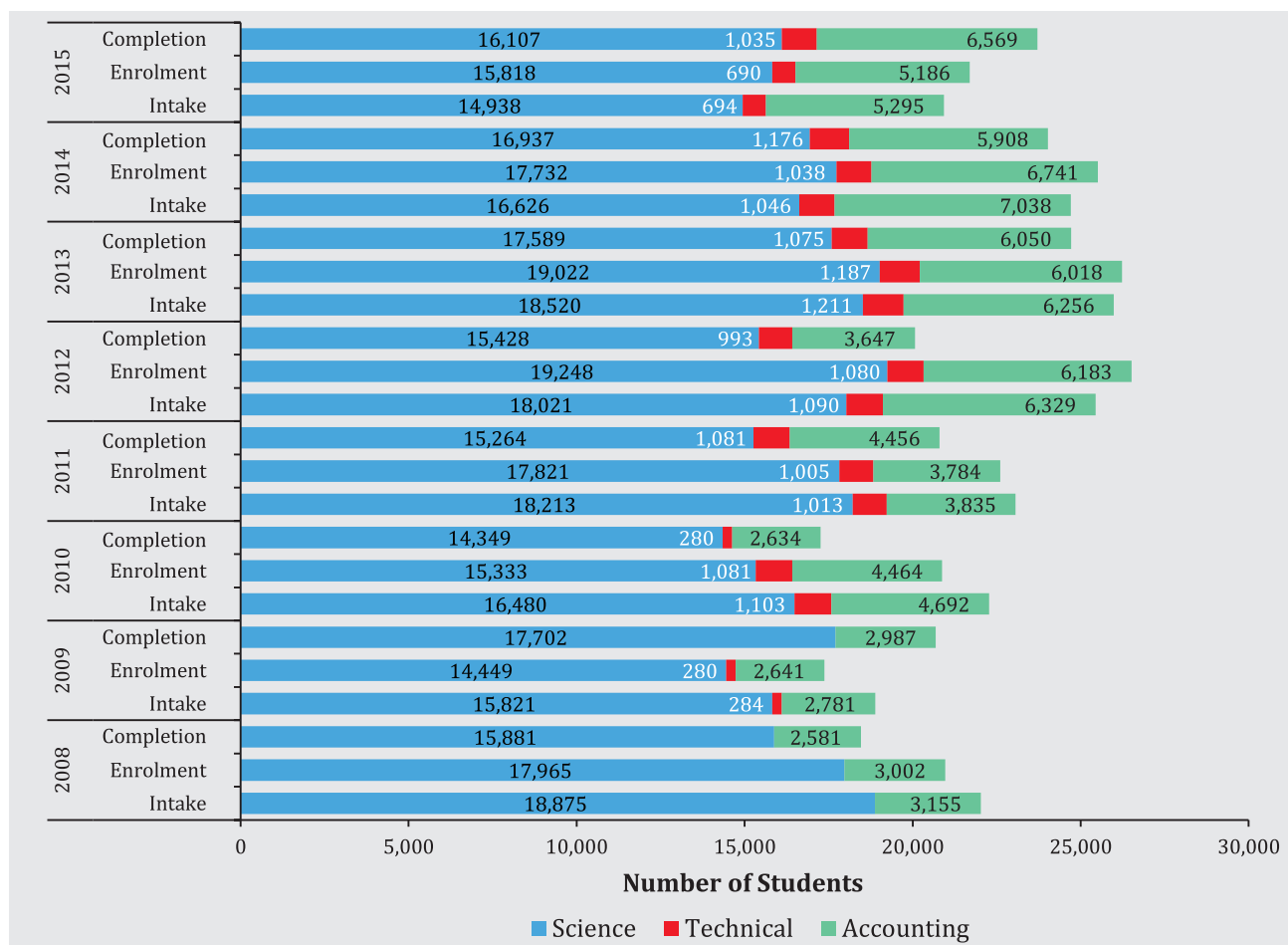
2013												
GRADE	Mathematics (M)		Mathematics (T)		ICT		Physics		Chemistry		Biology	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
A-, A	10.8	10.6	24.9	17.9	20.2	16.5	16.3	10.5	17.3	12.3	12.0	9.1
B-, B, B+	28.0	37.5	34.3	37.9	28.9	35.7	33.4	34.9	41.1	39.5	46.0	42.9
C-, C, C+	33.1	35.4	22.0	23.4	37.5	35.7	31.2	34.7	27.3	32.2	29.9	38.6
D, D+	10.4	7.5	7.8	8.6	8.3	6.8	10.9	10.5	8.3	10.4	7.8	7.7
F	17.8	9.1	11.0	12.3	5.1	5.3	8.2	9.4	6.1	5.6	4.2	1.7
2014												
A-, A	9.3	11.9	20.5	15.7	24.8	19.7	17.2	13.6	15.6	12.5	9.8	8.1
B-, B, B+	29.2	31.1	33.9	36.8	36.6	41.5	34.3	37.7	40.1	40.9	38.5	38.8
C-, C, C+	33.2	37.5	26.1	28.3	30.4	34.6	29.1	34.5	34.1	36.4	37.1	39.7
D, D+	8.2	8.0	8.4	8.9	6.8	3.2	11.7	9.3	7.2	7.3	10.4	10.4
F	20.2	11.5	11.1	10.3	1.2	1.1	7.6	4.8	3.0	2.8	4.2	3.0
2015												
A-, A	9.5	10.8	21.3	18.1	18.6	19.3	20.6	16.5	17.6	14.7	13.9	10.2
B-, B, B+	26.1	36.5	36.9	36.8	41.9	47.2	35.0	39.3	40.8	40.4	36.9	37.5
C-, C, C+	31.0	33.0	23.6	25.9	32.0	26.4	26.6	30.5	32.1	35.8	34.5	39.7
D, D+	11.7	8.0	7.1	9.4	2.9	2.8	8.8	7.7	7.4	7.9	10.2	9.5
F	21.7	11.7	11.2	9.8	4.7	4.3	8.9	6.0	2.1	1.2	4.6	3.1

Source : Malaysian Examinations Council

I. Enrolment and Completion in Malaysian Matriculation Programmes

Figure 2.6 shows the number of students registered for the three programmes offered for the period 2008 – 2015. Of the total enrolment, the Science programme recorded an enrolment of 85.7% in 2008, and declined over the years to a low of 69.5% in 2014. The enrolment for Technical and Accounting programmes has increased over the years.

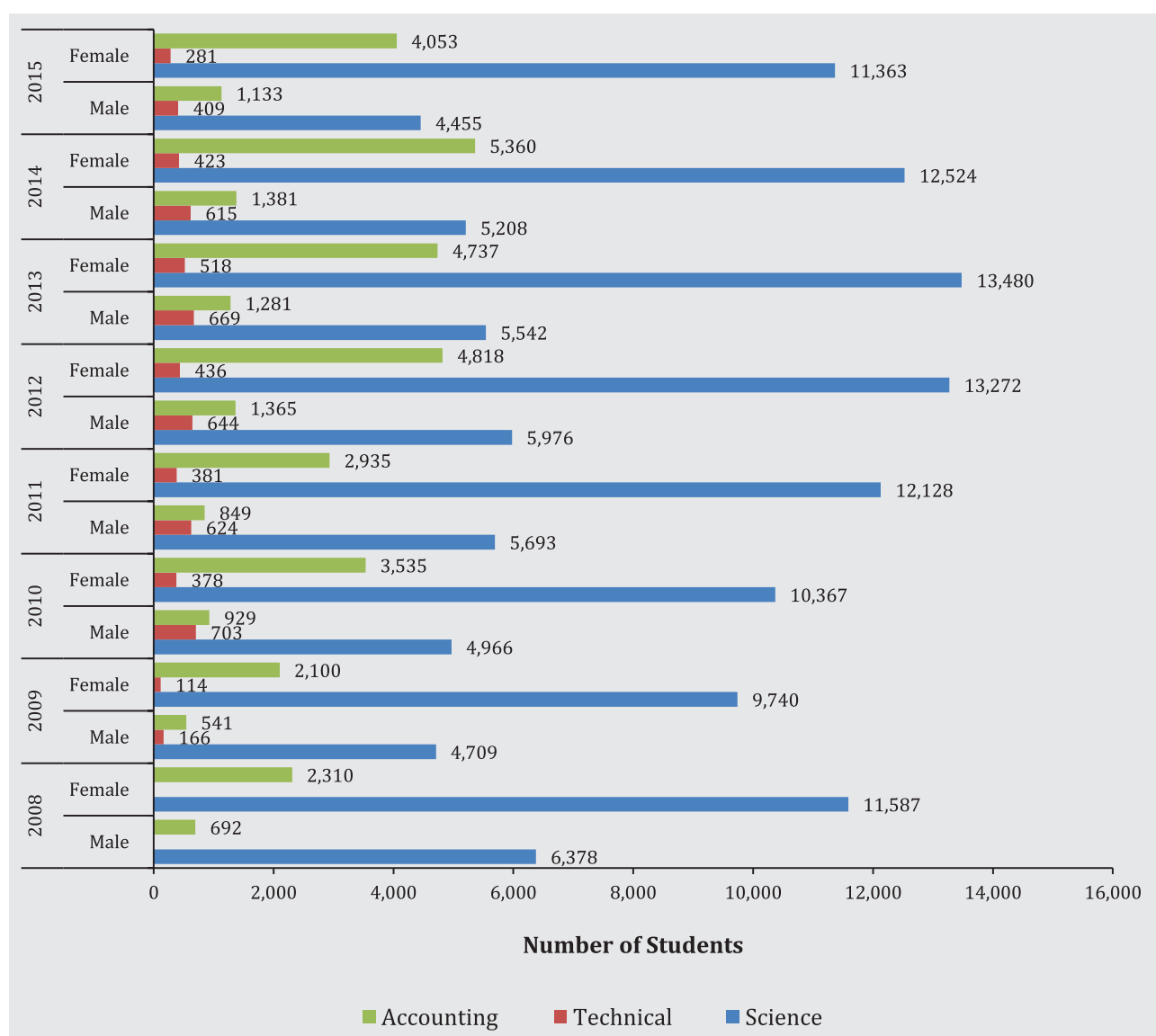
Figure 2.6 Intake, Enrolment and Completion for STEM in Matriculation Programmes



Source : Matriculation Division, Ministry of Higher Education

II. Enrolment and Completion in Matriculation Programmes by Gender

Figure 2.7 displays the distribution of students according to programmes by gender. In general, there are two times more females than males in science, while males make up approximately 60% – 65% of the enrolment in technical. On the other hand, accounting recorded about 80% female enrolment annually.

Figure 2.7 Enrolment in Matriculation Programmes, by Gender

Source : Matriculation Division, Ministry of Higher Education

2.3 Tertiary Education in Science and Technology at Public Higher Education Institutions

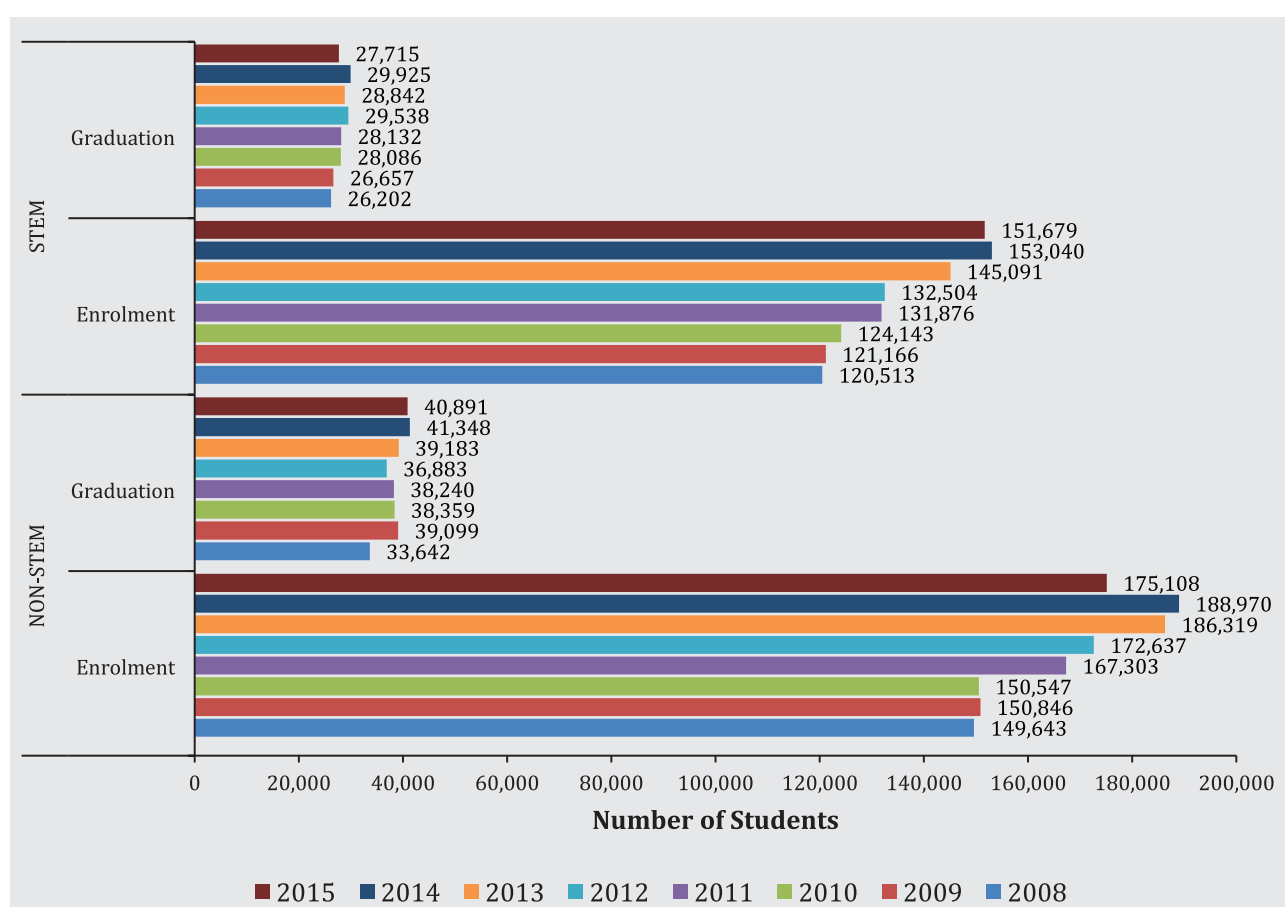
Currently, there are 20 public universities, 34 polytechnics, 94 community colleges and 497 private Higher Education Institutions (HLI) in Malaysia⁵ that offer courses leading to certificate, diploma, bachelor, master's, and doctoral degrees, in diverse areas including Science and Technology. The STEM programmes offered by public universities are classified under the NEC codes comprising these programmes: Life Science, Physical Science, Mathematics and Statistics, Computing, Engineering & Engineering Trades, Manufacturing & Processing, Architecture & Building, Agriculture, Forestry & Fishery, Veterinary, and Health. This section discusses the enrolment and graduations at the undergraduate and postgraduate levels for STEM programmes in public and private HLI.

⁵ As of 31st August 2016.

2.3.1 Enrolment and Graduation in First Degree Courses at Public Higher Education Institutions

The number of students enrolled in non-STEM courses at the first-degree level is consistently more than for STEM courses, i.e. around 54% to 57% of total annual enrolment, as shown in Figure 2.8. Likewise, the enrolment for non-STEM courses has steadily increased over this period (from 149,643 in 2008 to 175,108 in 2015). As for STEM courses, the number of students has remained relatively constant from 2008 to 2010, but increased steadily from 2011 to 2015; in 2015, the number of students enrolled in STEM courses totalled 151,679 (46% of 2015's total enrolment). The data also shows that the number of non-STEM graduates is consistently higher than STEM graduates, as expected given the size of enrolment – of the total 340,697 first degree graduates for 2011 – 2015, 42% are from STEM.

Figure 2.8 Enrolment and Graduation in First Degree Programmes



Source : Ministry of Higher Education, Malaysia

Table 2.4 displays the breakdown of STEM enrolment and graduation by programme of study at the First Degree level. Engineering & Engineering Trades related programmes have the highest annual intake (and hence enrolment) at the rates of 36% to 39% of all STEM intakes for the period 2008 – 2015. Also, Engineering & Engineering Trades, Computing, Physical Sciences and Health jointly contribute to an average of 70% – 72% of all STEM enrolment annually. These programmes aligned well with the National Key Economic Areas (NKEA) of the National Transformation Programme (NTP), as well as the skills given focus by the Ministry of Higher Education.

Table 2.4 Intake, Enrolment and Graduation in First Degree Programmes by Field of Study

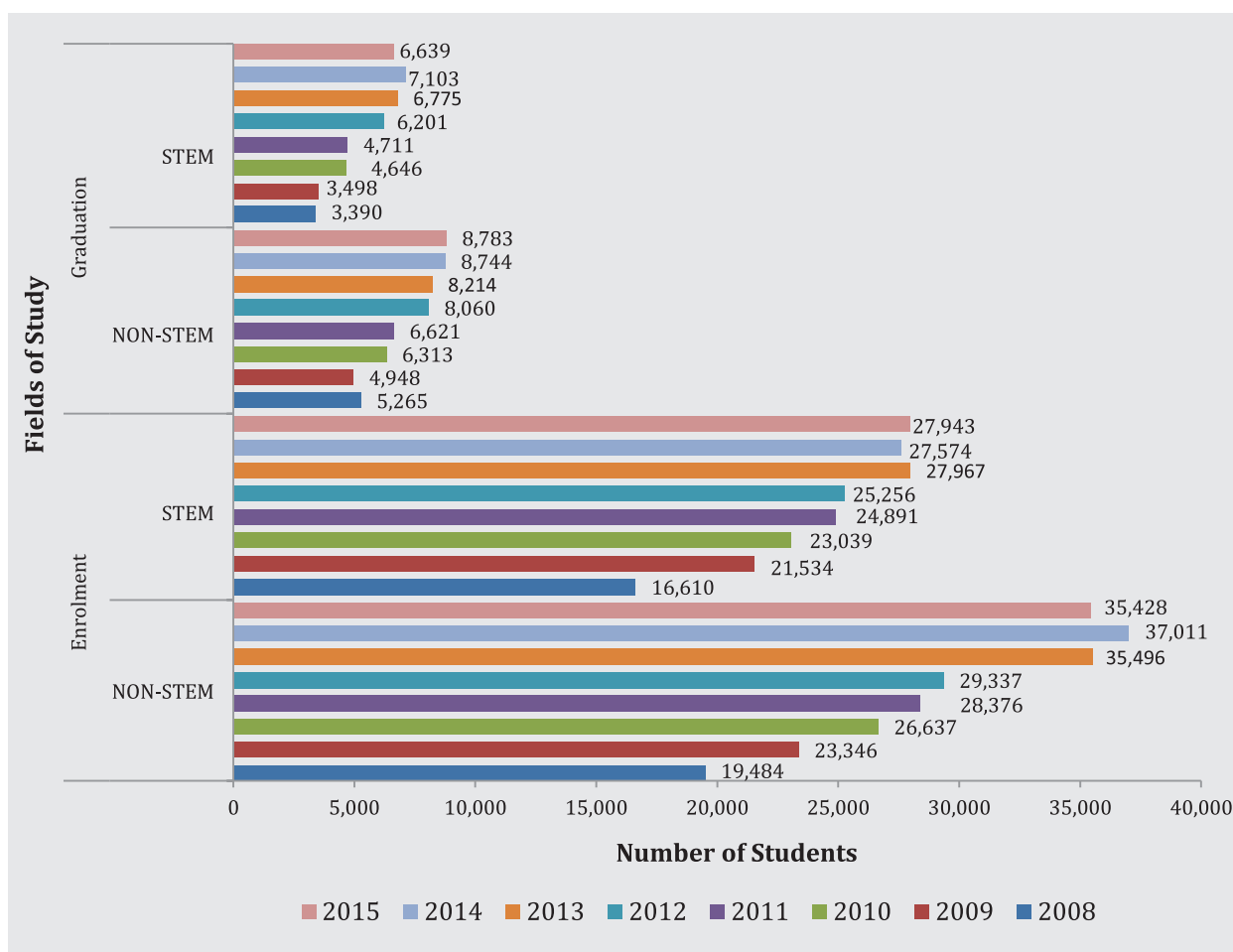
Year	Intake/ Enrolment/ Graduation	Life Science	Physical Science	Mathematics and Statistics	Computing	Engineering & Engineering Trades	Manufacturing & Processing	Architecture & Building	Agriculture, Forestry & Fishery	Veterinary	Health
2008	Intake	2,048	3,698	1,613	3,882	12,823	2,431	3,428	1,274	67	3,507
	Enrolment	5,920	11,956	4,873	13,365	47,378	7,714	11,364	3,785	333	13,825
	Graduation	1,787	3,370	1,059	2,997	9,847	1,710	2,482	973	61	1,916
2009	Intake	2,016	3,491	1,815	4,137	12,862	2,576	3,641	1,288	124	3,617
	Enrolment	6,242	11,630	5,041	13,418	46,142	8,470	10,990	4,007	385	14,841
	Graduation	1,649	3,015	1,288	3,097	9,350	2,012	2,855	962	61	2,368
2010	Intake	2,128	2,916	1,876	3,978	13,553	2,612	3,890	1,271	138	3,886
	Enrolment	6,829	9,842	5,621	13,536	48,221	8,450	11,669	4,046	447	15,482
	Graduation	1,912	2,668	1,455	3,122	10,136	1,851	3,025	1,077	63	2,777
2011	Intake	2,588	2,807	1,777	4,584	15,139	2,795	3,662	1,649	147	3,954
	Enrolment	7,230	9,624	5,659	14,478	52,084	9,135	11,785	4,646	536	16,699
	Graduation	1,757	2,829	1,430	2,820	10,230	1,937	3,147	1,068	56	2,858
2012	Intake	2,547	2,509	2,113	5,124	14,253	2,979	3,165	1,658	137	3,829
	Enrolment	7,465	8,802	6,041	15,395	52,505	9,343	11,052	4,821	601	16,479
	Graduation	1,916	2,617	1,373	3,043	11,405	2,058	3,343	1,154	65	2,564
2013	Intake	2,417	2,669	1,334	6,679	15,645	2,906	2,881	1,812	162	4,501
	Enrolment	8,219	9,361	5,962	19,187	56,178	10,348	10,395	5,536	682	18,554
	Graduation	1,685	2,152	1,447	2,841	10,893	2,088	3,239	1,032	73	3,392
2014	Intake	2,814	2,956	1,362	6,828	15,941	2,980	3,285	1,719	159	4,042
	Enrolment	8,638	9,725	5,615	22,089	58,982	10,839	10,046	5,732	742	19,160
	Graduation	2,051	2,201	1,548	2,916	11,021	2,264	3,104	1,230	115	3,475
2015	Intake	2,472	2,429	1,204	6,200	15,224	2,748	2,806	1,621	146	3,924
	Enrolment	8,587	9,427	5,065	22,250	58,867	10,782	9,763	5,765	730	18,550
	Graduation	1,920	1,971	1,494	3,158	11,030	1,983	1,913	1,314	114	2,770

Source : Ministry of Higher Education, Malaysia

2.3.2 Enrolment and Graduation in Master's Degree Programmes at Public Higher Education Institutions

Figure 2.9 shows an increasing trend in enrolment for Master's degree programmes from 2008 to 2015. As in the First Degree level, a similar trend is also observed for the number of graduates, where non-STEM graduates are consistently more than that of STEM.

Figure 2.9 Enrolment and Graduation in Master’s Degree Programmes



Source : Ministry of Higher Education, Malaysia

In terms of programme of study, there is an increasing trend in enrolment for Health related programmes – an increase from 18% of all STEM enrolment in 2008, to 24% in 2014. Meanwhile, Engineering & Engineering Trades continued to increase steadily, from 28% in 2008 to 32% in 2012, and experienced a slight decline from 2013 – 2015. Also, the Engineering & Engineering Trades, Manufacturing & Processing, Computing, and Health jointly contributed to more than 70% of all STEM enrolment in Master’s Degrees annually (Table 2.5).

Table 2.5 Intake, Enrolment and Graduation in Master's Degree Programmes by Field of Study

Year	Intake/ Enrolment/ Graduation	Life Science	Physical Science	Mathematics and Statistics	Computing	Engineering & Engineering Trades	Manufacturing & Processing	Architecture & Building	Agriculture, Forestry & Fishery	Veterinary	Health
2008	Intake	340	608	624	1,080	2,000	499	333	371	30	1,268
	Enrolment	843	1,397	1,116	2,628	4,683	1,335	815	713	100	2,980
	Graduation	149	243	241	583	968	209	218	111	14	654
2009	Intake	401	669	452	1,017	2,714	844	557	385	28	1,134
	Enrolment	1,018	1,823	813	2,806	6,382	2,028	1,069	842	107	4,646
	Graduation	148	247	195	593	1,067	274	236	78	12	648
2010	Intake	429	616	395	1,041	2,675	717	532	308	28	1,493
	Enrolment	1,334	2,046	835	2,939	6,634	2,037	1,117	1,099	112	4,886
	Graduation	203	332	252	722	1,496	386	287	128	19	821
2011	Intake	642	631	494	1,143	3,523	856	665	344	28	1,604
	Enrolment	1,789	1,890	942	2,629	7,699	2,296	1,346	992	99	5,209
	Graduation	255	351	304	675	1,582	459	288	125	12	660
2012	Intake	488	516	499	1,056	3,049	666	538	232	28	1,363
	Enrolment	1,722	1,651	1,049	2,687	7,953	2,424	1,411	928	100	5,331
	Graduation	380	416	361	796	2,077	542	361	135	18	1,115
2013	Intake	493	400	443	1,074	3,261	738	696	267	26	1,626
	Enrolment	1,864	1,672	973	2,964	8,628	2,665	1,627	1,073	111	6,310
	Graduation	411	407	393	776	2,536	515	413	163	8	1,153
2014	Intake	645	551	476	1,199	3,326	863	706	315	36	1,763
	Enrolment	2,044	1,648	912	2,946	8,150	2,502	1,545	997	100	6,637
	Graduation	433	419	430	837	2,624	526	513	142	16	1,161
2015	Intake	656	579	548	970	2,870	763	784	364	32	1,732
	Enrolment	2,069	1,730	1,053	2,817	8,147	2,551	1,782	1,133	104	6,469
	Graduation	406	438	286	740	2,382	540	439	161	24	1,219

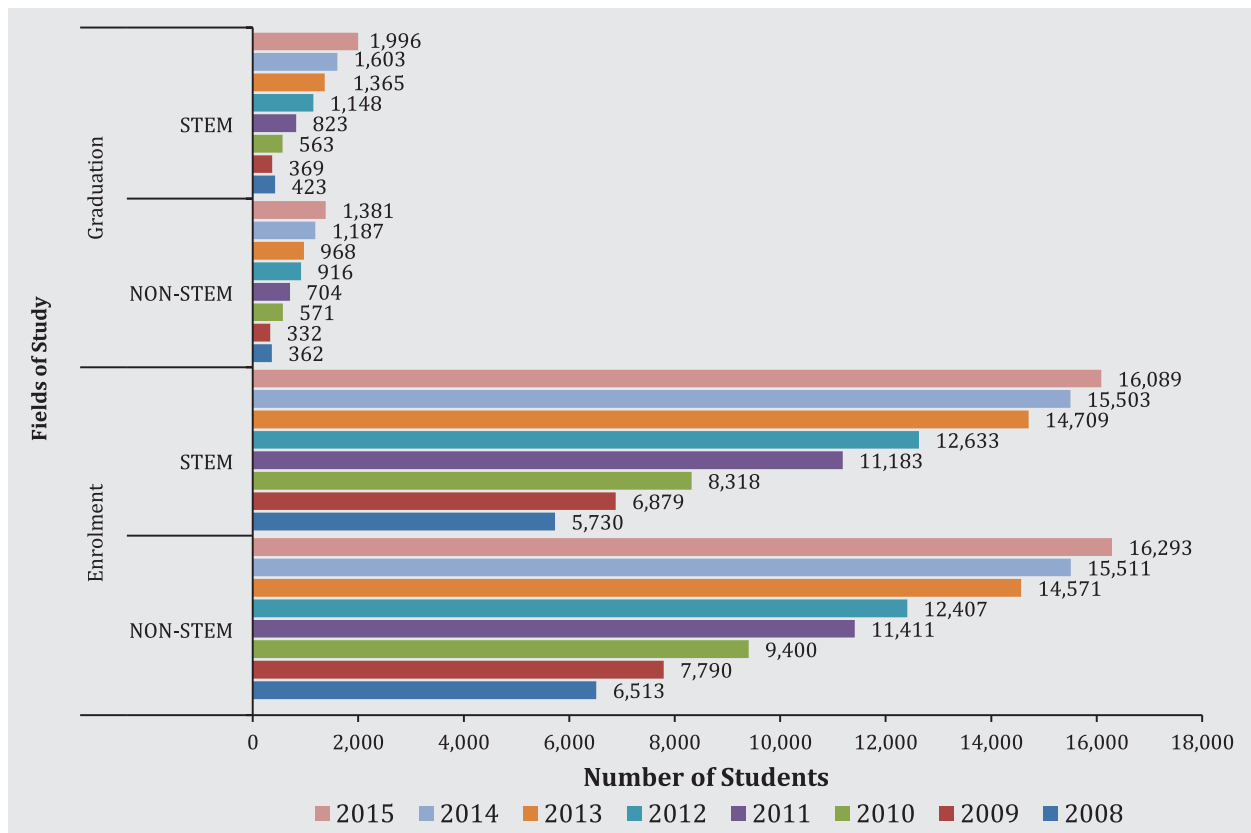
Source : Ministry of Higher Education, Malaysia

2.3.3 Enrolment and Graduation in Doctoral Degree Programmes

The student enrolment in doctoral degree courses increased over the years 2008 – 2015, and especially in 2012, for STEM as well as non-STEM courses. This aligns with the objective of MyBrain15 of Pelan Strategik Pengajian Tinggi Negara (PSPTN⁶) 2007 – 2020, which aims to produce a sufficient number of Doctor of Philosophy (PhD) or equivalent graduates, who will be drivers of innovation to mobilise the country's economic competitiveness. The STEM enrolment (for doctoral programmes) in 2011 is double that of 2008 and has increased to date, although relatively slower. A total of 12,091 PhD holders were produced in 2011 – 2015, of which 6,935 (i.e. 57%) are STEM related (Figure 2.10).

⁶ Pelan Tindakan Pengajian Tinggi Negara Fasa 2 (2011 – 2015): Mencetus Transformasi Pengajian Tinggi, Kementerian Pengajian Tinggi, Malaysia.

Figure 2.10 Enrolment and Graduation in Doctoral Degree Programmes



Source : Ministry of Higher Education, Malaysia

There is an increasing trend in intake and hence enrolment for Engineering & Engineering Trades; this constitutes 29% – 39% (2008 – 2015) of all STEM annual intake and 30% – 35% of enrolment. Health related programme also records a healthy increase of enrolment from 2008 – 2015; the highest intake recorded was in 2011. Also, the Engineering & Engineering Trades, Computing, Life and Physical Sciences and Health related programmes jointly contribute approximately 75% – 82% of all STEM enrolment at Doctoral Degree programmes annually (Table 2.6).

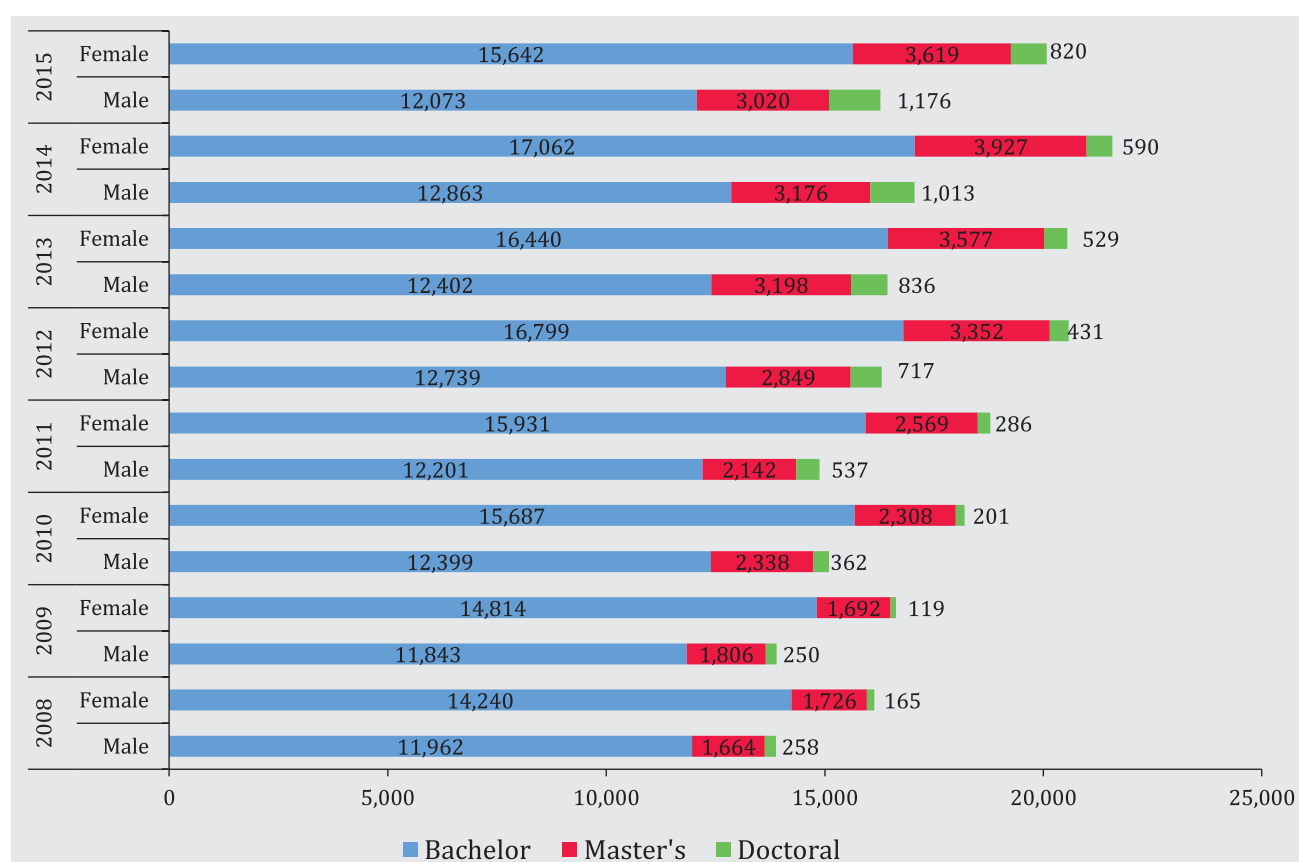
Table 2.6 Intake, Enrolment and Graduation in Doctoral Degree Programmes by Field of Study

Year	Intake/ Enrolment/ Graduation	Life Science	Physical Science	Mathematics and Statistics	Computing	Engineering & Engineering Trades	Manufacturing & Processing	Architecture & Building	Agriculture, Forestry & Fishery	Veterinary	Health
2008	Intake	176	189	111	315	517	71	105	74	14	215
	Enrolment	544	562	316	983	1,688	271	398	257	66	645
	Graduation	25	48	37	67	122	25	16	22	5	56
2009	Intake	186	191	99	362	693	51	152	40	16	216
	Enrolment	413	625	306	1,169	2,166	502	488	321	74	815
	Graduation	25	45	27	56	105	26	25	6	6	48
2010	Intake	135	225	114	388	792	52	137	32	17	286
	Enrolment	648	890	443	1,436	2,775	254	534	158	88	1,092
	Graduation	58	71	36	75	181	26	24	6	7	79
2011	Intake	181	353	175	564	1,389	166	217	95	9	421
	Enrolment	949	1,006	584	1,797	3,905	500	729	347	73	1,293
	Graduation	111	65	50	101	243	66	41	35	18	93
2012	Intake	291	214	137	476	1,074	154	195	93	12	272
	Enrolment	1,253	956	653	2,064	4,432	622	938	369	57	1,289
	Graduation	174	86	71	139	338	72	84	49	21	114
2013	Intake	369	233	139	513	1,221	183	150	95	20	356
	Enrolment	1,489	1,100	682	2,351	5,205	780	1,002	426	64	1,529
	Graduation	148	136	110	181	430	71	84	43	15	146
2014	Intake	355	235	154	476	1,189	201	172	106	20	342
	Enrolment	1,592	1,166	711	2,428	5,468	851	982	458	68	1,652
	Graduation	175	158	86	213	542	78	103	37	14	197
2015	Intake	317	180	131	336	994	182	155	86	13	315
	Enrolment	1,695	1,153	734	2,381	5,767	910	982	470	74	1,760
	Graduation	219	188	88	284	717	103	121	69	10	197

Source : Ministry of Higher Education, Malaysia

2.3.4 Degrees Awarded in Science and Technology from Public Higher Education Institutions by Gender

Figure 2.11 displays the number of degrees awarded in Science and Technology (STEM) at public universities by gender, for the period 2008 – 2015. For the bachelor's degree programmes, there are more female graduates than male (for example, of the 144,152 graduates in 2011 – 2015, only 43% are male). This is contrary to what is observed for the doctoral degree programmes, where males dominate 62% of the 6,935 graduates in 2011 – 2015.

Figure 2.11 Degrees Awarded in Science and Technology by Gender

Source : Ministry of Higher Education, Malaysia

2.4 Tertiary Education in Science and Technology at Private Higher Education Institutions

Private higher educational institutions have demonstrated an increasingly important role in the Malaysian Higher Education system. This section discusses the trend in enrolments and graduations of students for Science and Technology, as well as non-science courses at the Bachelor (or First Degree), Master's and Doctoral levels.

2.4.1 Enrolment and Graduation at Private Higher Education Institutions

Table 2.7 illustrates the trend in enrolment for the period 2008 – 2015 at private HLIs, for both STEM and non-STEM programmes. Enrolments in non-STEM programmes are consistently more than STEM programmes at all First Degree, Master's and Doctoral programmes. The trend in STEM per total enrolment declined⁷ over the years at all levels of study: from 40% to 23% for undergraduate degrees, 35% to 11% for Master's, and 58% to 22% for Doctoral programmes. In terms of the number of graduates produced, as expected there are more non-STEM graduates compared to STEM graduates at all levels.

⁷ Partly affected by exclusion of some science programmes: Agriculture & Forestry, Veterinary and Health. In addition, the data reported is based on 'complete' data submitted – for example, in 2011, the data is based on 87.7% 'complete' data submitted.

Table 2.7 Intake, Enrolment and Graduation at Private Higher Education Institutions

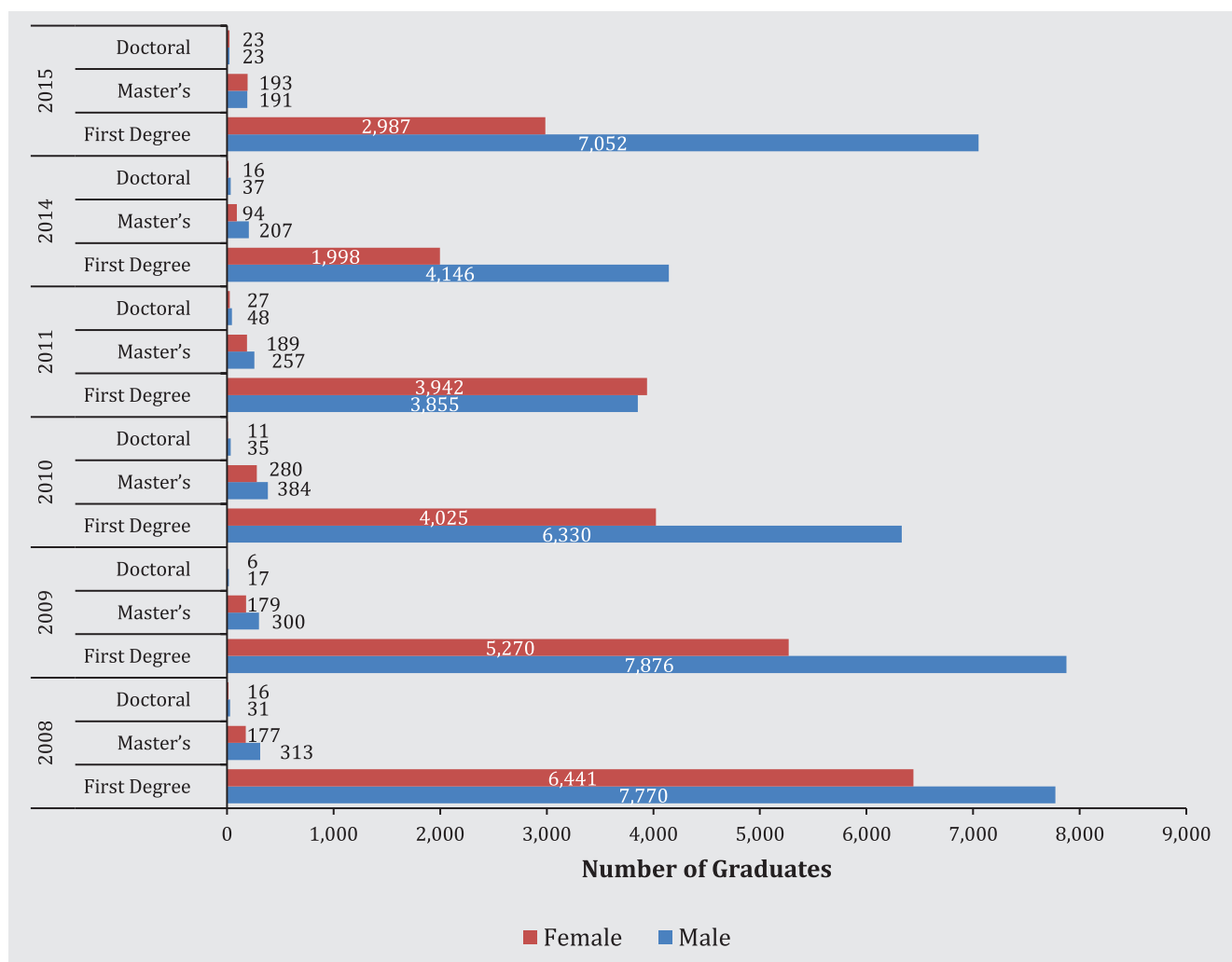
Year	Enrolment/ Graduation	STEM			NON-STEM		
		BACHELOR	MASTER'S	DOCTORATE	BACHELOR	MASTER'S	DOCTORATE
2008	Enrolment	69,910	3,898	1,066	103,407	7,148	770
	Graduation	14,211	490	47	14,984	840	39
2009	Enrolment	66,886	3,884	948	131,874	9,488	1,330
	Graduation	13,127	479	23	27,277	1,016	26
2010	Enrolment	74,149	3,501	1,516	146,150	10,537	2,288
	Graduation	10,355	664	46	16,207	1,209	88
2011	Enrolment	58,707	4,479	1,048	121,358	9,838	4,802
	Graduation	7,280	327	75	18,244	1,173	1,251
2014	Enrolment	47,877	1,860	437	160,796	11,478	1,528
	Graduation	6,144	301	53	16,745	1,245	158
2015	Enrolment	53,074	1,620	652	177,439	12,957	2,285
	Graduation	10,039	384	46	39,130	3,423	286

Source : Ministry of Higher Education, Malaysia

2.4.2 Degrees Awarded in Science and Technology from Private Higher Education Institutions by Gender

For the Bachelor and Master's Degree programmes in Science and Technology, males contribute between 55% – 70% to the total number of graduates over the period 2008 – 2014. Likewise, the male graduates are more dominant at the Doctoral level, contributing 64% – 76% to the total number of Doctoral holders for 2008 – 2014, as shown in Figure 2.12.

Figure 2.12 Degrees Awarded in Science and Technology by Gender at Private Higher Education Institutions



Source : Ministry of Higher Education, Malaysia

2.5 Enrolment and Graduation in MTUN TVET Degree Courses

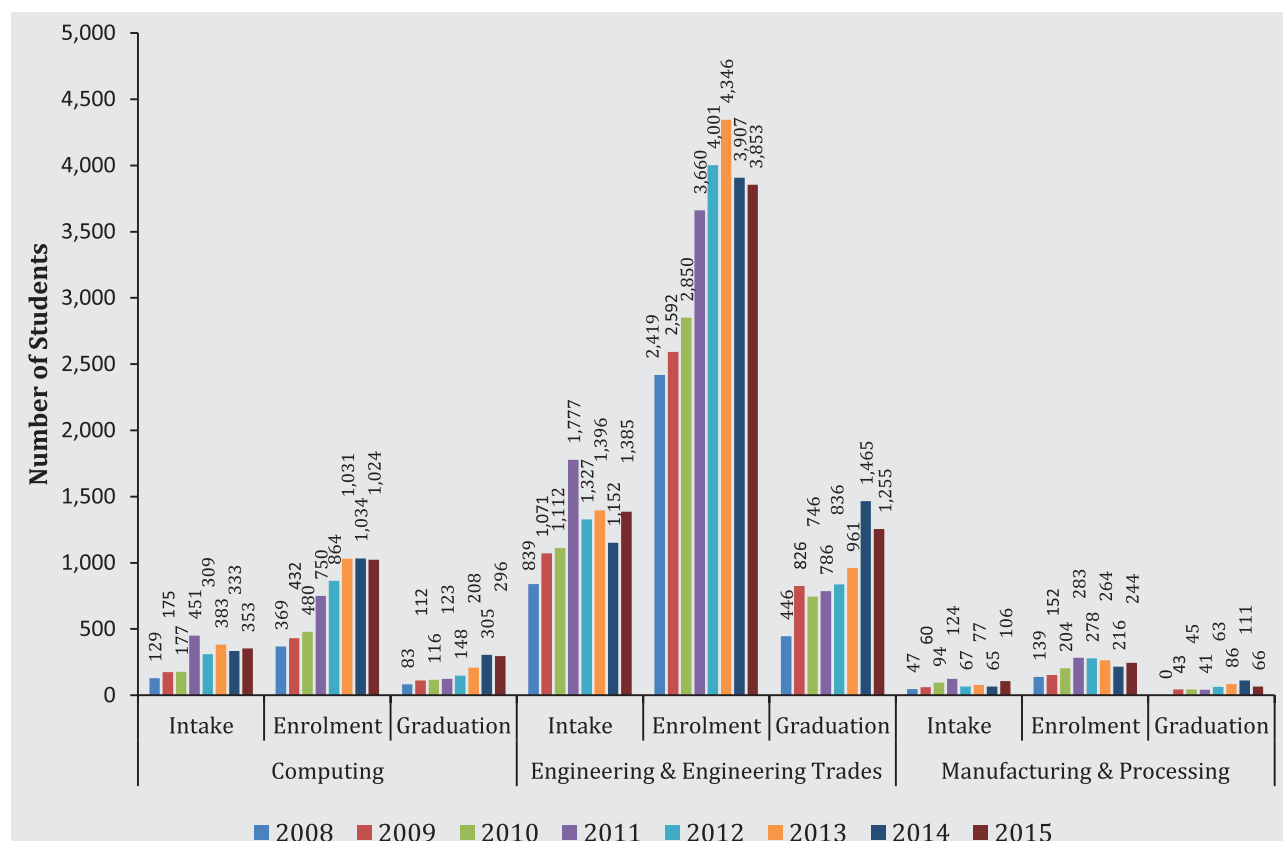
Technical and Vocational Education and Training (TVET) is defined by UNESCO as “those aspects of the educational process involving, in addition to general education, the study of technologies and related sciences and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupation in various sectors of economic life”. The definition of TVET in the context of National Higher Education is:

“Bachelor of Technology Programmes, Diploma and Certificate of Technology with a practical component of at least 40% of the curriculum, and the teaching and learning (T&L) are conducted at the public and private institutions; or

Programmes that do not use the word “technology” but comprise of a practical component of at least 40% of the curriculum, and the teaching and learning (T&L) are conducted at the public and private institutions.”

The TVET⁸ Diploma programmes offered under Malaysia Technical Universities (MTUN) focus on three core programmes, namely: Computing; Engineering and Engineering Trades; and Manufacturing & Processing. Figure 2.13 displays the enrolment and graduation in TVET Diploma Programmes. Engineering and Engineering Trades makes up 83% of all STEM enrolment in 2008, but this has subsequently declined to 75% in 2015. An increasing trend for intake and enrolment is observed for Computing over 2008 – 2015, and this is as expected from the SPM outcomes as discussed in subsection 2.2.1.

Figure 2.13 Intake, Enrolment and Graduation in TVET Diploma Courses at MTUN



Source : Ministry of Higher Education, Malaysia

The TVET Degree Programmes offered under MTUN focus mainly on the following core programmes: Computing; Engineering and Engineering Trades; Manufacturing & Processing; and Architecture & Building. Table 2.8 displays the enrolment and graduation in TVET First Degree Programmes. Engineering and Engineering Trades accounts for more than 75% of all STEM enrolment, followed by Computing (10% – 14%) and Manufacturing & Processing (4% – 9%). Meanwhile, an increasing trend is observed for Computing and Manufacturing Processing in recent years. Similar trends are also observed for graduations.

The TVET Degree Programmes offered by non-MTUN focus mainly on Computing, Engineering and Engineering Trades, Manufacturing & Processing, Architecture & Building, Agriculture, Forestry & Fishery, and Health. Table 2.9 displays the enrolment and graduation in TVET Degree Programmes at non-MTUN; Engineering and Engineering Trades, Computing, Architecture & Building and Agriculture, Forestry & Fishery jointly contributed approximately more than 80% of all STEM programmes. Similar trends are also observed for graduations.

⁸ TVET covers programmes offered at MTUN, as these are subset of public universities.

Table 2.8 Intake, Enrolment and Graduation in TVET First Degree Programmes at MTUN

Fields		2008	2009	2010	2011	2012	2013	2014	2015
Non-STEM	Intake	426	926	1,054	1,999	1,536	1,562	2,003	1,859
	Enrolment	1,072	1,792	2,479	3,983	4,758	5,515	6,358	6,458
	Graduation	291	392	276	300	591	825	878	1,661
Life Sciences	Intake	0	0	0	0	0	0	23	30
	Enrolment	0	0	0	0	0	0	23	51
	Graduation	0	0	0	0	0	0	0	0
Physical Sciences	Intake	0	0	0	0	55	57	58	56
	Enrolment	0	0	0	0	54	110	167	222
	Graduation	0	0	0	0	0	0	0	0
Mathematics and Statistics	Intake	0	0	0	0	109	113	110	121
	Enrolment	0	0	0	0	108	221	332	446
	Graduation	0	0	0	0	0	0	0	0
Computing	Intake	741	773	806	1,050	1,041	1,128	987	972
	Enrolment	1,583	2,192	2,573	3,080	3,330	4,237	4,755	3,990
	Graduation	308	326	346	353	400	472	421	749
Engineering & Engineering Trades	Intake	4,993	5,346	5,907	7,154	6,706	7,028	6,815	7,023
	Enrolment	14,188	16,010	18,124	20,597	22,010	24,152	25,644	26,247
	Graduation	2,121	3,230	3,409	3,726	4,744	4,750	4,773	5,583
Manufacturing & Processing	Intake	276	332	415	532	662	634	828	861
	Enrolment	631	830	1,088	1,430	1,821	2,091	2,745	3,002
	Graduation	57	193	101	152	227	269	354	492
Architecture & Building	Intake	81	84	129	98	180	154	133	185
	Enrolment	184	254	334	358	443	537	556	638
	Graduation	43	84	11	61	86	53	109	95
Agriculture, Forestry & Fishery	Intake	0	0	0	0	38	47	48	49
	Enrolment	0	0	0	0	38	85	133	179
	Graduation	0	0	0	0	0	0	0	0

Source : Ministry of Higher Education, Malaysia

Table 2.9 Intake, Enrolment and Graduation in First Degree TVET Programmes at Non-MTUN Universities

Fields		2008	2009	2010	2011	2012	2013	2014	2015
Non-STEM	Intake	14,092	18,042	21,665	27,013	25,495	15,900	14,896	12,734
	Enrolment	35,174	39,807	47,801	64,993	55,063	47,453	44,476	37,922
	Graduation	7,810	10,888	9,723	9,513	11,596	13,520	14,737	14,276
Life Sciences	Intake	0	0	0	0	0	208	0	0
	Enrolment	0	0	0	0	0	566	0	0
	Graduation	0	0	0	0	0	198	0	0
Physical Sciences	Intake	0	0	0	0	0	521	0	0
	Enrolment	0	0	0	0	0	1,515	0	0
	Graduation	0	0	0	0	0	390	0	0
Mathematics and Statistics	Intake	0	0	0	0	0	0	0	0
	Enrolment	0	0	0	0	0	0	0	0
	Graduation	0	0	0	0	0	0	0	0
Computing	Intake	844	1,555	1,700	1,764	1,239	2,025	2,463	2,437
	Enrolment	2,796	3,351	4,016	5,364	4,503	4,819	5,667	6,583
	Graduation	981	970	775	550	853	1,164	1,191	1,085
Engineering & Engineering Trades	Intake	2,738	3,485	4,657	3,916	3,415	3,301	3,538	4,096
	Enrolment	9,508	9,293	11,097	13,583	11,744	10,681	10,461	10,953
	Graduation	2,760	3,236	2,281	2,245	2,350	3,407	3,053	2,917

Table 2.9 Intake, Enrolment and Graduation in First Degree TVET Programmes at Non-MTUN Universities

Fields	2008	2009	2010	2011	2012	2013	2014	2015
Intake	985	921	1,509	1,316	1,002	409	502	484
Enrolment	1,150	1,414	1,932	2,443	1,642	1,091	1,159	1,259
Graduation	269	279	286	221	185	333	331	269
Intake	1,508	1,840	1,886	1,764	1,642	1,755	2,600	1,702
Enrolment	4,922	4,914	4,980	5,600	4,714	4,776	5,532	5,566
Graduation	1,446	1,671	1,518	1,227	1,110	1,386	1,422	1,309
Intake	910	1,622	1,636	1,550	1,879	1,893	2,157	2,016
Enrolment	1,480	2,421	3,622	4,727	4,319	4,552	5,162	5,385
Graduation	245	226	329	643	1,189	1,197	1,158	1,369
Intake	0	0	0	0	0	0	0	0
Enrolment	0	0	0	0	0	0	0	0
Graduation	0	0	0	0	0	0	0	0
Intake	1,002	932	662	822	576	720	892	627
Enrolment	1,972	2,396	2,206	2,781	1,752	2,173	2,898	1,719
Graduation	321	495	578	693	685	762	546	407

Source : Ministry of Higher Education, Malaysia

2.6 Malaysian Student Performance at International Level

The performance of Malaysian students in Mathematics and Science at the international level can be evaluated by the scores attained in the OECD Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) examination. The OECD Programme for International Student Assessment (PISA) is a triennial international survey which aims at evaluating the problem solving skills and knowledge of 15-year-old students in three key areas: reading, mathematics and science. TIMSS, on the other hand, focuses on formal mathematical knowledge, thus measuring more traditional classroom content among the 4th and 8th graders internationally (an equivalent to Malaysia's 10-year-olds and 14-year-olds respectively).

2.6.1 Malaysian Student Performance in PISA

Despite the improvements in student achievements in the SPM, Malaysian students lag behind many of their Asian peers on global exams. In PISA, Malaysia ranks 52 out of 65 countries based on mathematics mean score (421), ranks 53 on science (420), and ranks 59 on reading (398) in PISA 2012 (Table 2.10); these lead to Malaysia being at the bottom third cohort among all participating countries. In contrast to Malaysia, other Asian entrants such as Singapore, Japan and Korea attained the highest scores in mathematics, reading and science. A difference of 38 points on the PISA scale is equivalent to one year of schooling. A comparison of scores shows that 15-year-olds in Singapore, South Korea, and Japan are performing as though they have had 3 or more years of additional schooling compared to 15-year-olds in Malaysia.

Table 2.10 Achievement Scores in Reading, Mathematics and Science, PISA

Country	2009			2012		
	Reading	Mathematics	Science	Reading	Mathematics	Science
Selected Asian Countries						
Malaysia	414	404	422	398	421	420
Singapore	526	562	501	542	573	551
Thailand	421	419	425	441	427	444
Vietnam	-	-	-	508	511	528
Indonesia	402	371	383	396	375	382
Japan	520	529	539	538	536	547
South Korea	539	546	538	536	554	538
Other Countries						
Australia	515	514	527	512	504	521
USA	500	487	502	498	481	497
OECD	493	496	501	496	494	501

Note : The test is based on a 1000-point scale.

Source : OECD PISA 2012 Database

In terms of Mathematics literacy proficiency levels, 51.8% of Malaysia's 15-year-old students (from the sample) attained at most Level 1, and only 1.3% achieved Level 5 or above. In Science, the literacy proficiency levels stood at 45.5% for at most Level 1, and 0.3% with Level 5 or above. Table 2.11 provides a snapshot of the 15-year-old students' proficiency levels for some selected countries.

Table 2.11 Students' Proficiency Levels: Percentage of 15-year-old student's performance, PISA 2012

Country	Reading		Mathematics		Science	
	Level 1a and below	Level 5 and Above	Level 1 and below	Level 5 and Above	Level 1 and below	Level 5 and Above
Selected Asian Countries						
Malaysia	52.7	-	51.8	1.3	45.5	0.3
Singapore	9.9	21.2	8.3	40.0	9.6	22.7
Thailand	33.0	0.8	49.7	2.5	33.6	0.9
Vietnam	9.4	4.5	14.2	13.3	6.7	8.1
Indonesia	55.2	-	75.7	-	66.6	-
Japan	9.8	18.5	11.1	23.6	8.4	18.2
South Korea	7.6	14.1	9.1	30.9	6.7	11.7
Other Countries						
Australia	14.2	11.7	19.6	14.8	13.6	13.5
USA	16.6	7.9	25.9	8.8	18.2	7.4
OECD	18.0	8.4	23.0	12.6	17.8	8.3

Note : Reading: Level 1a – a score in the range (334.75,407.47]; Level 5 – a score in the range (606.99, 669.30]. Mathematics: Level 1 – a score in the range (357.77 - 420.07]; Level 5 – a score in the range (606.99, 669.30]. Science: : Level 1 – a score in the range (334.94, 409.45]; Level 5 – a score in the range (633.33, 707.93].

Source : IES, National Center for Education Statistics (NCES)

Malaysia's performance in the OECD's PISA survey has always been significantly below the OECD global scores average. It is hoped that the newly launched Malaysia Education Blueprint 2013 – 2025 with national reform strategies can improve upon and sustain the quality and equity in education.

2.6.2 Malaysian Student Performance at TIMSS

In terms of measuring a formal mathematical knowledge through traditional classroom content, the TIMSS score is presented in Table 2.12. Over the years, the scores have declined and lag behind Singapore, South Korea, Japan, the United States and Thailand. Similar findings are obtained for Science scores as shown in Table 2.12. The results from both PISA and TIMSS can be used as indicators to reassess the educational policies implemented in order to improve teaching and learning in mathematics and science.

Table 2.12 Students Performance in Mathematics and Science, TIMSS

Mathematics Score					
Country	1995	1999	2003	2007	2011
Malaysia	-	519	508	474	440
Indonesia	-	403	411	397	386
Singapore	609	604	605	593	611
Thailand	516	467	-	441	427
Japan	581	579	570	570	570
South Korea	581	587	589	597	613
USA	492	502	504	508	509
Science Score					
Malaysia	-	492	510	471	426
Indonesia	-	435	420	427	406
Singapore	580	568	578	567	590
Thailand	510	482	-	471	451
Japan	554	550	552	554	558
South Korea	546	549	558	553	560
USA	513	515	527	520	525

Note : TIMSS Centre PointScale = 500. TIMSS achievement level: Advance (Score > 625), High (550 ≤ Score < 625), Intermediate (475 ≤ Score < 550), Low (400 ≤ Score < 475).

Source : TIMSS 2011 International Results in Mathematics, IEA & TIMSS 2011 International Results in Science, IEA; Mullis et al. (2012)

2.7 Summary

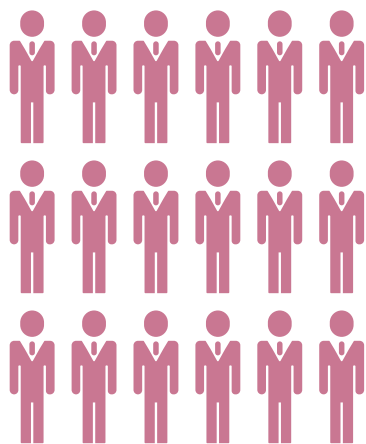
Generally, the number of enrolments for science and mathematics at the SPM level has increased over the period 2008 – 2013, with a slight decrease in 2014 – 2015. The performance of the students has improved over time, in the sense of increase in percentages of students scoring A and above for mathematics and science in 2008 – 2013. These trends are encouraging, and suggest that the implementation at the ministry level – leading to encouraging a deeper understanding in the subject matter through teaching and learning – has recorded some success. The performance of males at SPM is of concern, as the percentages of failure in Science and Mathematics are between two to three times higher than for females. This is also addressed in the Malaysia Education Blueprint, prompting the government to emphasise compulsory school years, as well as making education reforms in vocational education to address the poor performance of male students at this level.

At the STPM level, the number of registrations in science, mathematics and technology subjects has generally decreased; it is estimated that out of the total numbers of STEM enrolment at SPM, (with Mathematics (T) and Additional Mathematics as a base), less than 10% enrolled in STEM at STPM. This is could be due to a number of factors; among these are the desire to embark on a different path of interest that is outside the perimeter of Science and Technology, as well as enrolling at pre-university programmes such as Matriculation, A-levels, and International Baccalaureate (IB) programmes – where we cannot capture the information. The STPM examination results also indicate that the number of A's obtained for science and mathematics has generally been high and remained relatively consistent throughout the years. The number of failures for both science and mathematics illustrates a decreasing trend, which suggests an improvement in the understanding of science and

technology. In terms of gender disparity, more males scored A- and above than females, with marginal difference at grade F.

At public and private universities, the number of enrolments for science courses is consistently less than for non-science courses at the undergraduate and postgraduate levels. At public universities, the ratio of science to non-science undergraduate stands at around 45:55, far from the government's target of 60:40. The data also show that at the first degree level, there are more female graduates than male in Science and Technology courses; however, this is in contrast to the private universities. At the postgraduate degree programmes, more males are observed relative to females. At public universities, Engineering & Engineering Trades, Computing, Physical Sciences and Health jointly contribute more than 70% of all STEM undergraduate enrolment annually. This aligns well with NKEA of the NTP, as well as the research priority areas under the R,D&I funding under the Ministry of Higher Education and the Ministry of Science, Technology and Innovation.

At the international level, Malaysia's performance in the OECD's PISA and TIMSS surveys has always been significantly below OECD and TIMSS global score averages. Since a difference of 38 points on the PISA scale is equivalent to one year of schooling, a comparison of PISA scores shows that 15-year-olds in Singapore, South Korea, and Japan are performing as though they have had 3 or more years of additional schooling compared to 15-year-olds in Malaysia. PISA focuses on evaluating the problem solving skills and knowledge of 15-year-old students in Mathematics, Science and Reading Literacy, while TIMSS focuses on formal mathematical knowledge – hence these results should serve as an indicator that Malaysia must improve on the quality of learning and teaching in science and mathematics education.



Public Awareness of Science, Technology and Innovation



Public Interest in STI

Top interest:
The use of new inventions and technologies

	23.3%	Very Interested
	60.4%	Interested

Least interest:
Environmental pollution

	15.7%	Very Interested
	57.0%	Interested



Public Knowledge of STI Issues



Over the past 16 years, below **50%** of respondents were able to answer correctly the factual knowledge statements on STI in the surveys

In 2014 survey, the average percentage is

45.9%

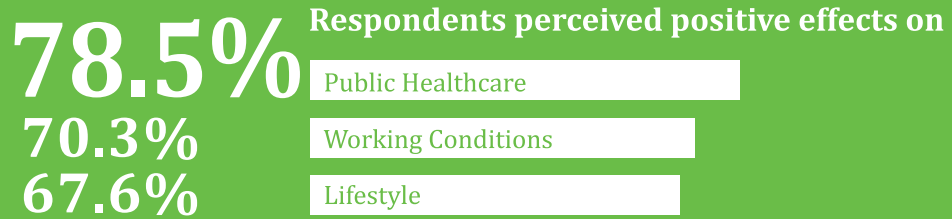
▶▶ CHAPTER 3



Public Attitude towards STI

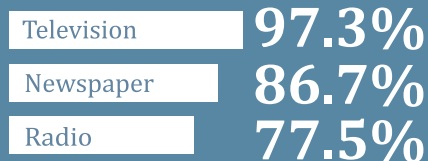


52.9% Respondents believe that scientific research brings more good than harm in 2014 survey



Information Sources on STI

Main source of information:

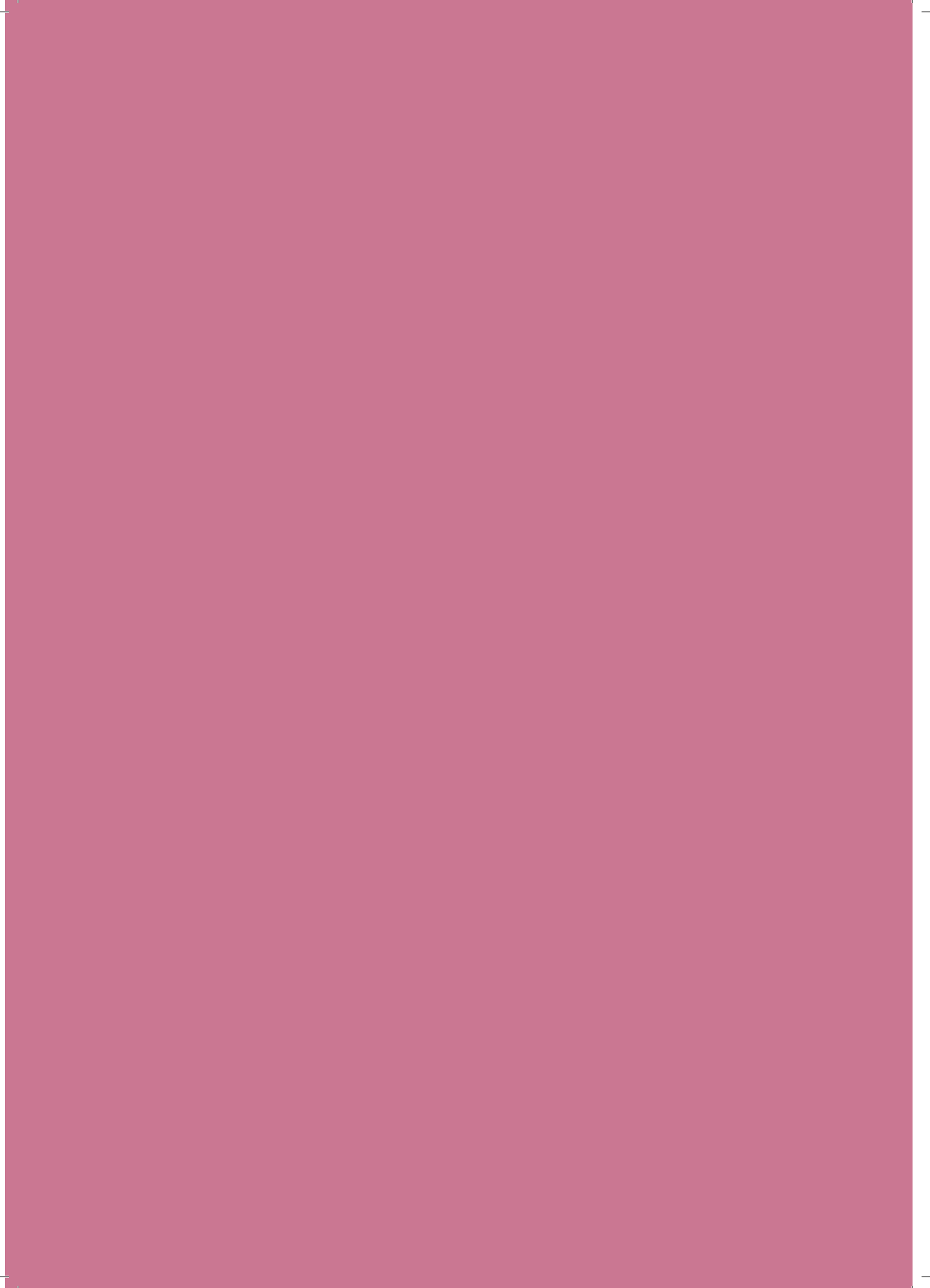


Main source of information on STI:



Main source of information on STI internationally:





CHAPTER 3: PUBLIC AWARENESS OF SCIENCE, TECHNOLOGY AND INNOVATION

3.1 Introduction

Science, Technology and Innovation is one of the key aspects to drive national economic growth and social progress. Hence, it is essential for Malaysian society to become scientifically literate in order to better understand and make decisions, as well as to effectively participate in improving productivity and quality of life through STI. Greater scientific literacy enables better adoption of STI in societal life, enabling Malaysia to become globally competitive. Awareness of STI is the first step towards such scientific literacy. Hence, understanding the public awareness of STI in Malaysia will help the country in its efforts towards achieving greater scientific literacy, charting the course to become a high-income economy by 2020.

Since 1994, the Malaysian Science and Technology Information Centre (MASTIC) has conducted national surveys on the public's awareness of science and technology in Malaysia, and following to that has published the Public Awareness of Science and Technology reports. The report on the most recent survey was published in 2014⁹, with a newly added component on the subject of innovation. Indeed, certain statements in this survey were rephrased. For ease of making a comparison against the 2008 Public Awareness report, Table 3.1 matches up the question items of 2008 versus 2014. This chapter reports on the public awareness and interest towards various STI issues in 2014, and compares with that of 2008 in order to analyse the trends. In addition, international benchmarking was conducted.

Table 3.1 Question Items Matching Between 2008 and 2014 Surveys

Question Items in 2008	Question Items in 2014
Latest inventions in science	New scientific discoveries
Latest inventions in the field of medicine	New medical discoveries
The use of computer technology	The use of new inventions and technologies
Innovations in telecommunication technology	Innovation
Environmental pollution	Environmental pollution
Inventions and new technologies in Malaysia	STI in Malaysia

Source : Public Awareness of STI Malaysia 2014

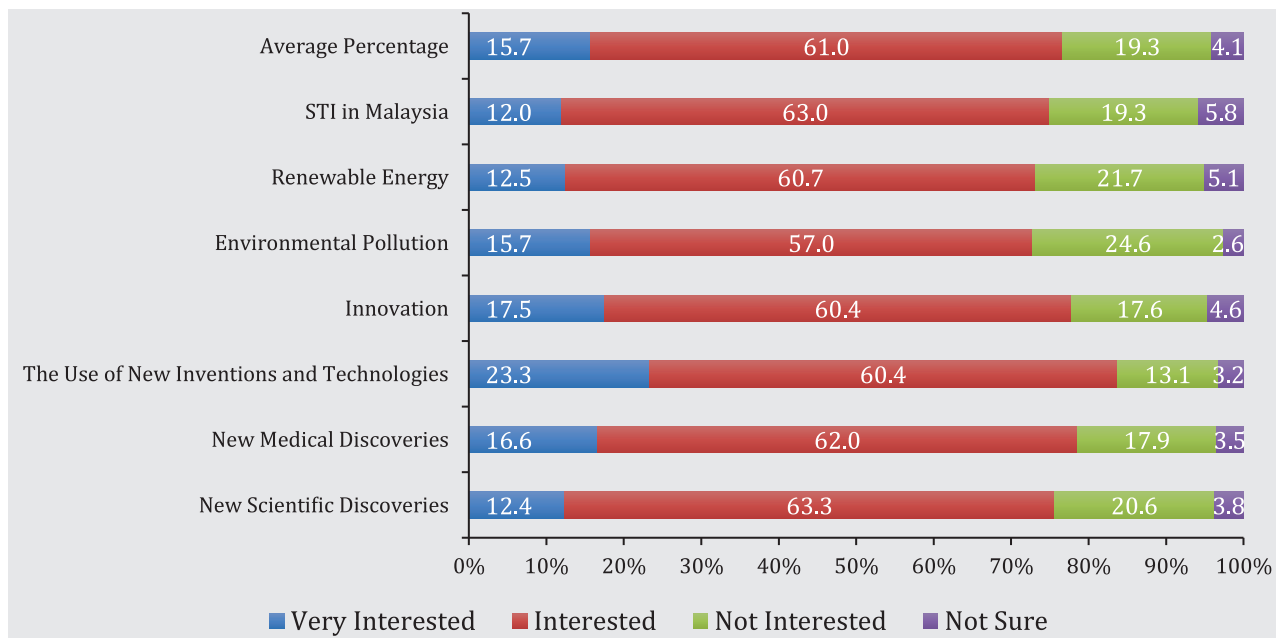
3.2 Public Interest in STI

The past Public Awareness of Science and Technology reports up until the 2008 report found that Malaysians are between slightly to moderately interested in science and technology issues. However, in 2014 Malaysians indicated that they are interested or very interested in the selected STI issues (Figure 3.1). In particular, public interest is high for the use of new inventions and technologies, new medical discoveries and innovation issues. The past

⁹ Sample for 2014 survey was drawn from the household sampling framework by Department of Statistics Malaysia. Respondents are selected from all Malaysians aged between 12 and 64 years old, and permanent residents in Malaysia.

1998 – 2008 reports reveal that there is a declining interest in environmental pollution issues among Malaysians. Similarly, in 2014 the trend continues and shows that the environmental pollution issues record the highest proportion of respondents who are not interested (24.6%, Figure 3.1) compared to other selected issues.

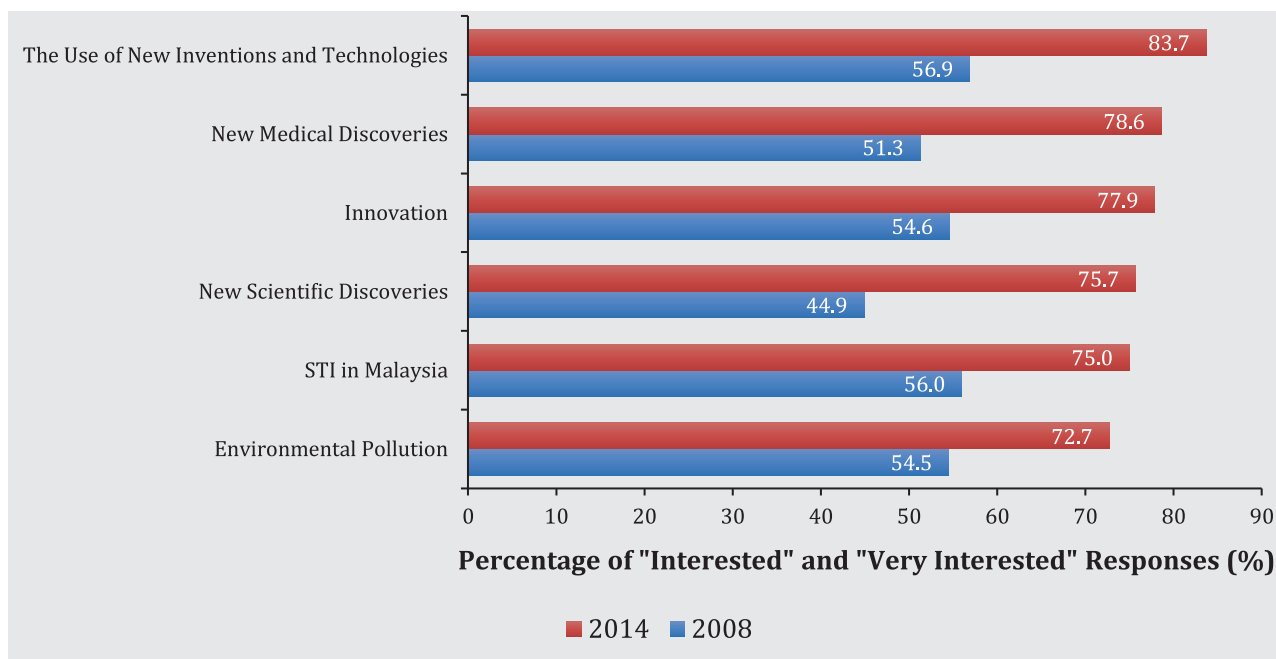
Figure 3.1 Public Interest in Selected STI Issues, 2014



Source : Public Awareness of STI Malaysia 2014

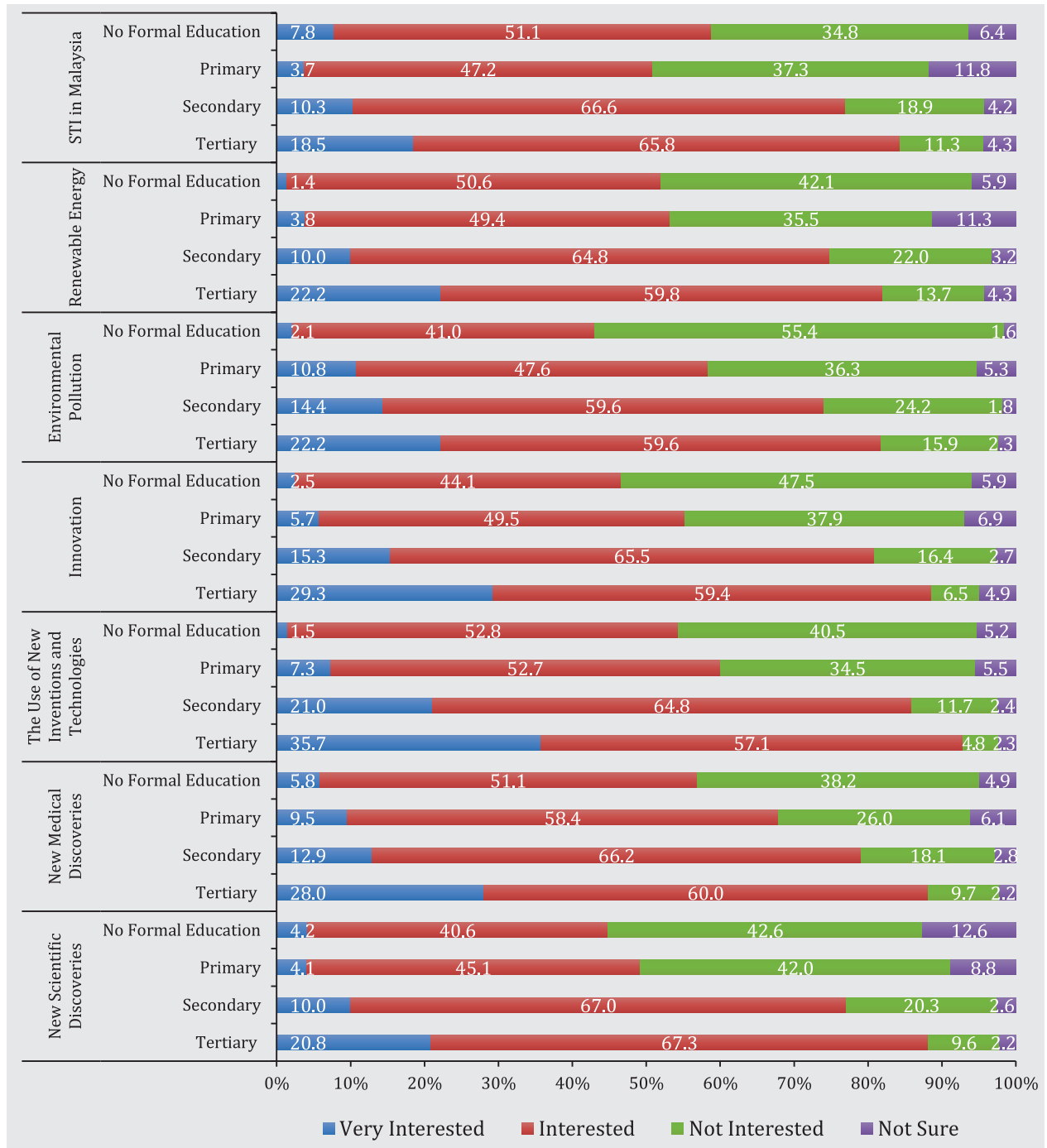
Comparing public interest in selected STI issues between 2008 and 2014 shows that interest has generally improved over the years. Figure 3.2 indicates that in 2014 there was an increase to about three quarters of the respondents in all STI related issues.

Figure 3.2 Public Interest in Selected STI Issues, 2008 and 2014



Both the 2008 and 2014 findings suggest that education level is highly correlated to level of interest in STI issues. Generally, Malaysians with a higher level of education indicate a higher degree of interest in STI issues (Figure 3.3).

Figure 3.3 Public Interest in Selected STI Issues by Level of Education, 2014



Source : Public Awareness of STI Malaysia 2014

3.3 Public Knowledge of STI Issues

Public knowledge of STI is gauged through two aspects: (i) the correct understanding of STI terms and concepts; and (ii) the ability to differentiate between science and pseudoscience. The percentage of respondents providing correct True/False answers to the scientific concepts and statements in 2014 gives an indication of the Malaysian public's understanding of STI terms and concepts, and hence the public knowledge of STI.

3.3.1 STI Terms and Concepts

Table 3.2 shows that the average percentage of Malaysians answering correctly has – surprisingly – been decreasing, from 49.1% in 2000 to 36.6% in 2008. Although there is a marked improvement in the average percentage in 2014 (45.9%) compared to 2008 (36.6%), this percentage is slightly lower compared to the proportions in 1998 (48.3%) and 2000 (49.1%).

Table 3.2 Responses on Scientific Concepts and Statements (%), 1998 – 2014

Scientific Concepts and Statements	Percentage with Correct Answers (%)					
	1998	2000	2002	2004	2008	2014
Physical Science						
The earth travels around the sun (True)	82.5	80.9	76.3	70.9	72.6	84.9
The centre of the earth is very hot (True)	72.1	74.3	62.8	58.2	66.0	74.7
The continents have been moving their location for millions of years and will continue to move (True)	63.6	62.2	44.0	45.1	44.4	61.8
Electrons are smaller than atoms (True)	40.5	42.0	37.0	26.4	33.0	35.0
Lasers work by focusing sound waves (False)	30.6	34.1	13.2	19.2	15.5	30.3
All radioactivity is man-made (False)	31.4	33.0	14.5	13.4	14.0	20.2
Biological Science						
It is the father's gene that determines the gender of the baby (True)	45.8	46.0	46.6	37.8	39.5	45.2
Antibiotics kill viruses as well a bacteria (False)	19.8	20.6	16.2	15.5	7.6	15.5
Average percentage of respondents who answered correctly (Regardless of statement)	48.3	49.1	38.8	35.8	36.6	45.9

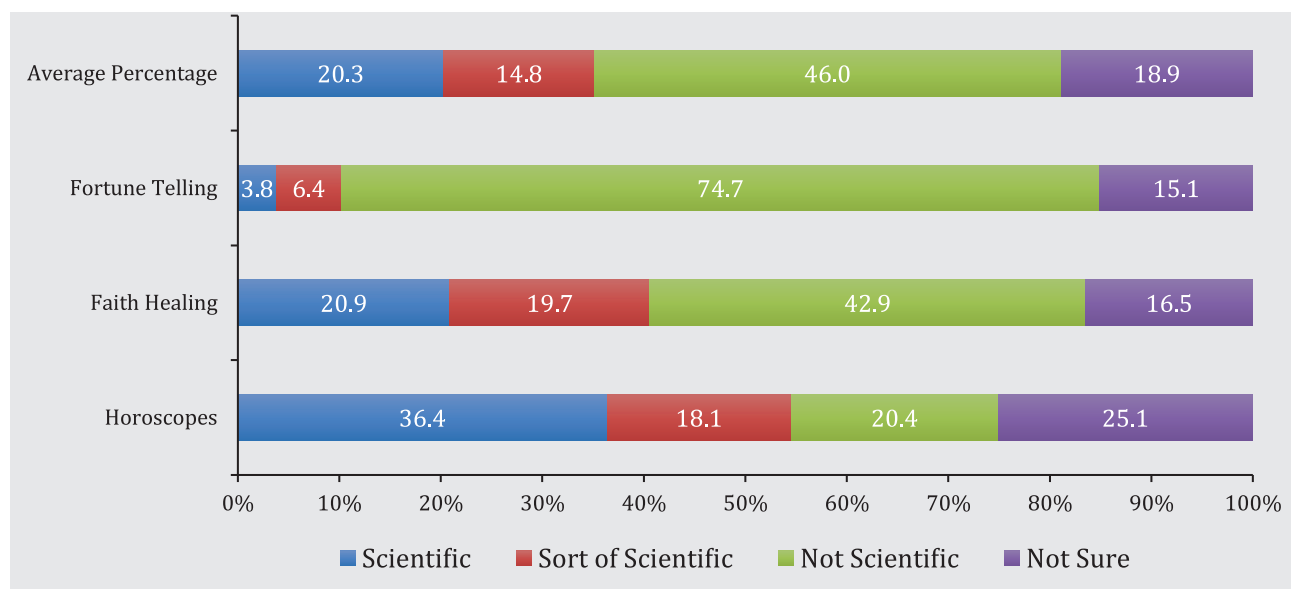
Source : Public Awareness of STI Malaysia 2014

As indicated in Table 3.2, the average public knowledge of STI in Malaysia has been below 50% for the past 16 years. Nevertheless, public knowledge concerning some physical science statements such as “the earth travels around the sun” and “the centre of the earth is very hot” is well above 50% over the years. This may not be surprising since these are basic science concepts taught in Malaysian schools. However, it may be a cause for concern that there appears to be a decreasing percentage of respondents answering correctly for the statement “antibiotics kill viruses as well as bacteria” over the years. Nevertheless, in comparison to 2008 the percentage of respondents answering correctly to specialised statements such as “lasers work by focusing sound waves” and “all radioactivity is man-made” is markedly higher in 2014.

3.3.2 Pseudoscience

In 2014, respondents were also asked to assess whether horoscopes, faith healing and fortune telling are pseudoscience. A majority of the respondents are aware that fortune telling is a pseudoscience (74.7%). However, slightly more than one third have the perception that horoscopes are based on the scientific method (Figure 3.4). In 2014 similar findings are observed regardless of respondents’ level of education, although there are slightly higher percentages of respondents with a higher level of education recognizing that horoscopes, faith healing and fortune telling are pseudoscience.

Figure 3.4 Public Assessment of Selected Pseudoscience Topics, 2014



Source : Public Awareness of STI Malaysia 2014

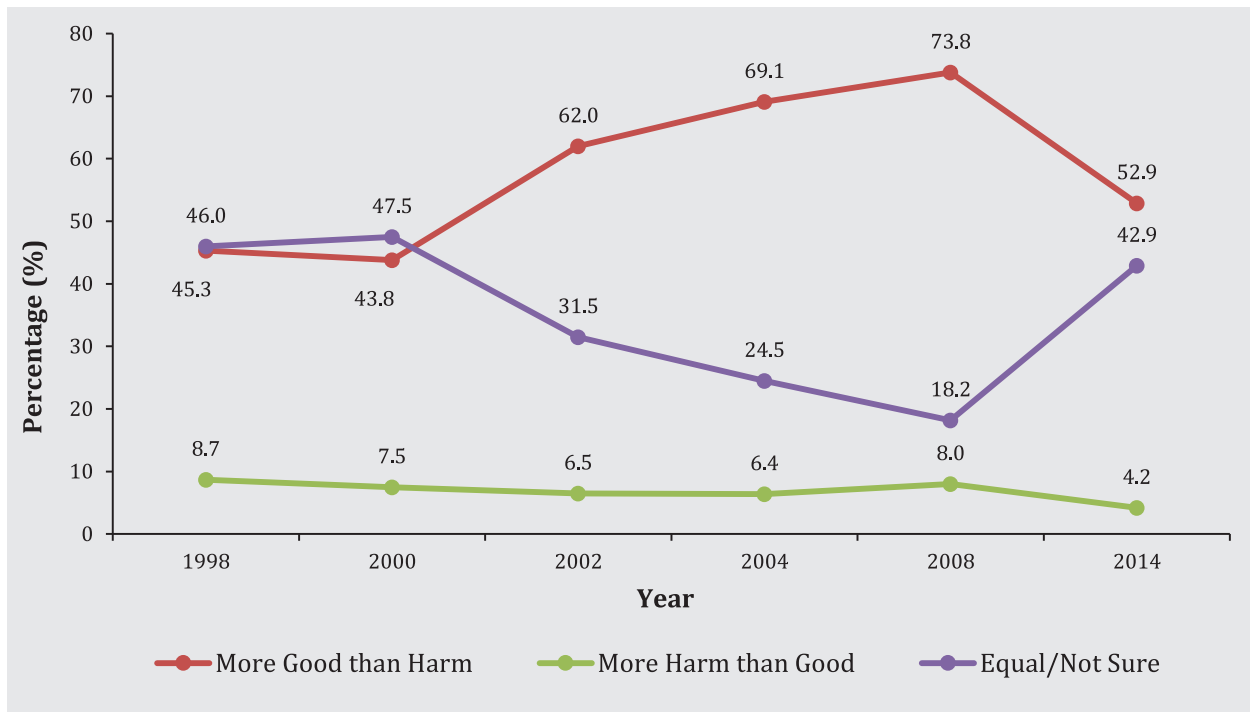
3.4 Public Attitudes Towards STI

The public attitudes towards STI – particularly on their perception of positive, negative or neutral effects of STI on their lives – have been assessed since 1998. Knowing the public attitudes toward STI may help policymakers – for example, in charting an effective course of action as needed to garner public support for STI advancement. The latest findings in 2014 are described in the following sections.

3.4.1 Public Assessment of Scientific Research

Generally, the percentage of respondents believing that scientific research brings more good than harm increased, from 45.3% in 1998 to 73.8% in 2008. However, this percentage dipped sharply to 52.9% in 2014. Nevertheless, the percentage of respondents believing that scientific research brings more harm than good is much smaller by comparison, and generally declined – from 8.7% in 1998 to 4.2% in 2014. From 2008 to 2014, there was also a notable increase in the percentage of respondents who either believe that the benefits from scientific research are about equal to the harmful results, or are not sure (42.9%, Figure 3.5). This may be due to a wider circulation of information on the misuse and abuse of scientific research results by unethical parties, which may have caused respondents to be more sceptical of the benefits of scientific research.

Figure 3.5 Public Assessment of Scientific Research, 1998 – 2014



Source : Public Awareness of STI Malaysia 2014

3.4.2 Public Attitudes Towards STI, Scientific Research and Science

In 2014 the trends continue to show that Malaysians view STI positively, with more than 75% of the respondents agreeing with the statements “Science, Technology and Innovation are very important for the progress of our nation”, “Science, Technology and Innovation improve the quality of our lives” and “We need scientific knowledge in order to manage our daily lives better” (Table 3.3). However, in 2014 there were also more respondents than in 2008 who agreed that “We depend too much on science and not enough on faith” and “Science causes our lifestyles to change too fast”.

Table 3.3 Public Attitudes Towards Science and Technology, 1998 – 2014

Statements	Percentage Agreeing with Statement (%)					
	1998	2000	2002	2004	2008	2014
We depend too much on science and not enough on faith	27.4	25.3	21.7	26.9	39.2	41.8
Science causes our lifestyles to change too fast	71.4	70.3	54.2	66.3	66.1	80.8
Scientific research increases knowledge although it does not produce immediate benefits	80.5	81.6	64.4	50.2	59.7	81.4
We need scientific knowledge in order to manage our daily lives better	83.5	81.2	62.9	75.5	68.7	88.1
Science, Technology and Innovation improve the quality of our lives	83.9	87.1	80.6	74.2	84.3	91.8
Science, Technology and Innovation are very important for the progress of our nation	n.a.	n.a.	77.9	77.9	79.8	94.5

Note : n.a. = not available

Source : Public Awareness of STI Malaysia 2014

3.4.3 Public Attitudes Towards the Impact of STI

As Table 3.4 indicates, in 2014 most Malaysians perceived that STI has positive effects on public healthcare (78.5%), followed by working conditions (70.3%) and lifestyle (67.6%). Since 1998 there is increasing percentage of Malaysians perceiving positive effects of STI particularly on the environment, cost of living and world peace. However, the perception of positive effects of STI on working conditions has been decreasing over the years. STI advancement may have pressured Malaysians to perform at a greater pace, leading to a more negative outlook on their working conditions.

Table 3.4 Public Attitudes Towards the Positive Effects of STI, 1998 – 2014

Statements	Percentage Indicating Positive Effects (%)					
	1998	2000	2002	2004	2008	2014
Cost of Living	40.3	39.6	43.3	49.1	56.0	62.6
Public Healthcare	63.4	62.1	74.4	74.4	71.1	78.5
Working Conditions	89.1	89.5	82.1	78.8	67.3	70.3
Environment	39.3	36.0	42.1	52.9	54.1	66.4
Lifestyle	67.8	70.7	65.0	63.0	59.9	67.6
World Peace	39.6	36.5	46.8	48.8	44.6	54.2

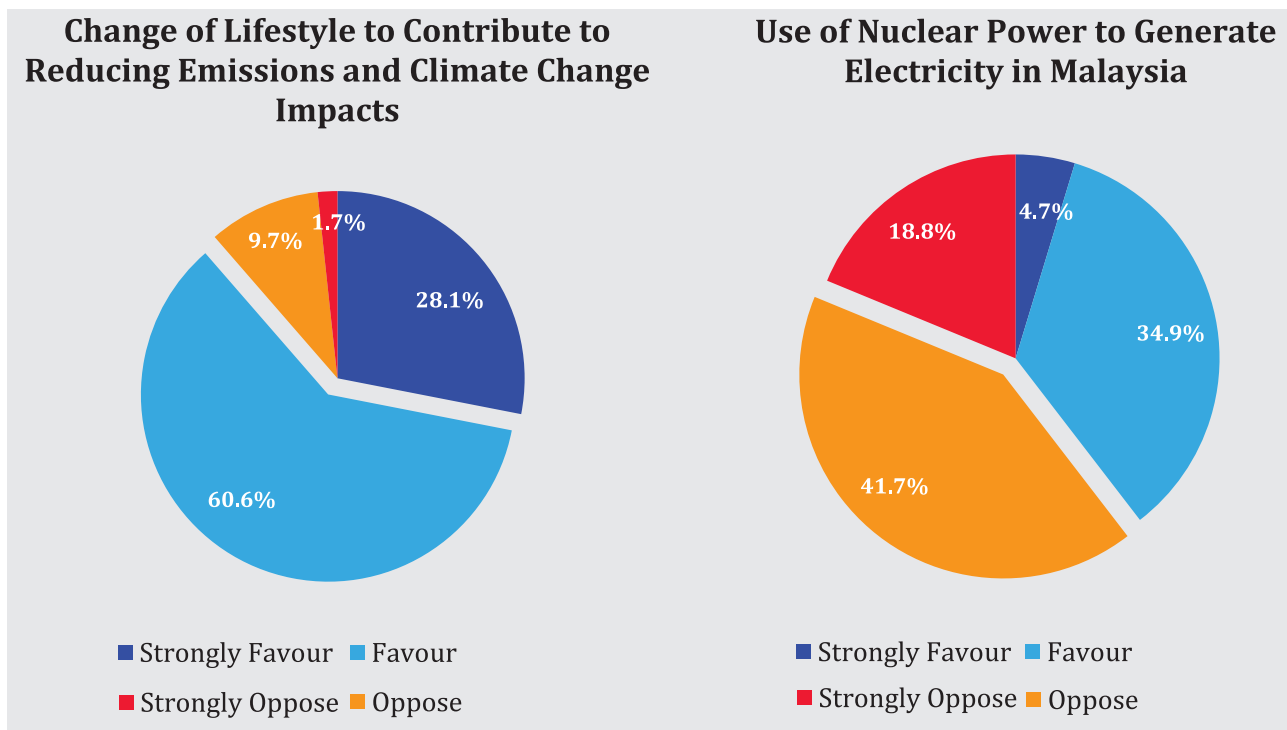
Note : In the 2014 survey, "individual enjoyment of life" has been rephrased as "lifestyle".

Source : Public Awareness of STI Malaysia 2014

3.4.4 Climate Change and Nuclear Power

Malaysians were asked about their views on two emerging topics, namely climate change and nuclear power. The survey found that 89.7% of Malaysians have read or heard of climate change, while 82.4% of them have read or heard of nuclear power. A majority of them (88.7%) expressed their willingness to change their lifestyle in order to reduce emissions and climate change impacts (Figure 3.6). In contrast, most Malaysians (60.5%) are opposed to the use of nuclear power to generate electricity in Malaysia.

Figure 3.6 Support for Emerging Issues, 2014



Source : Public Awareness of STI Malaysia 2014

3.5 Information Sources on STI

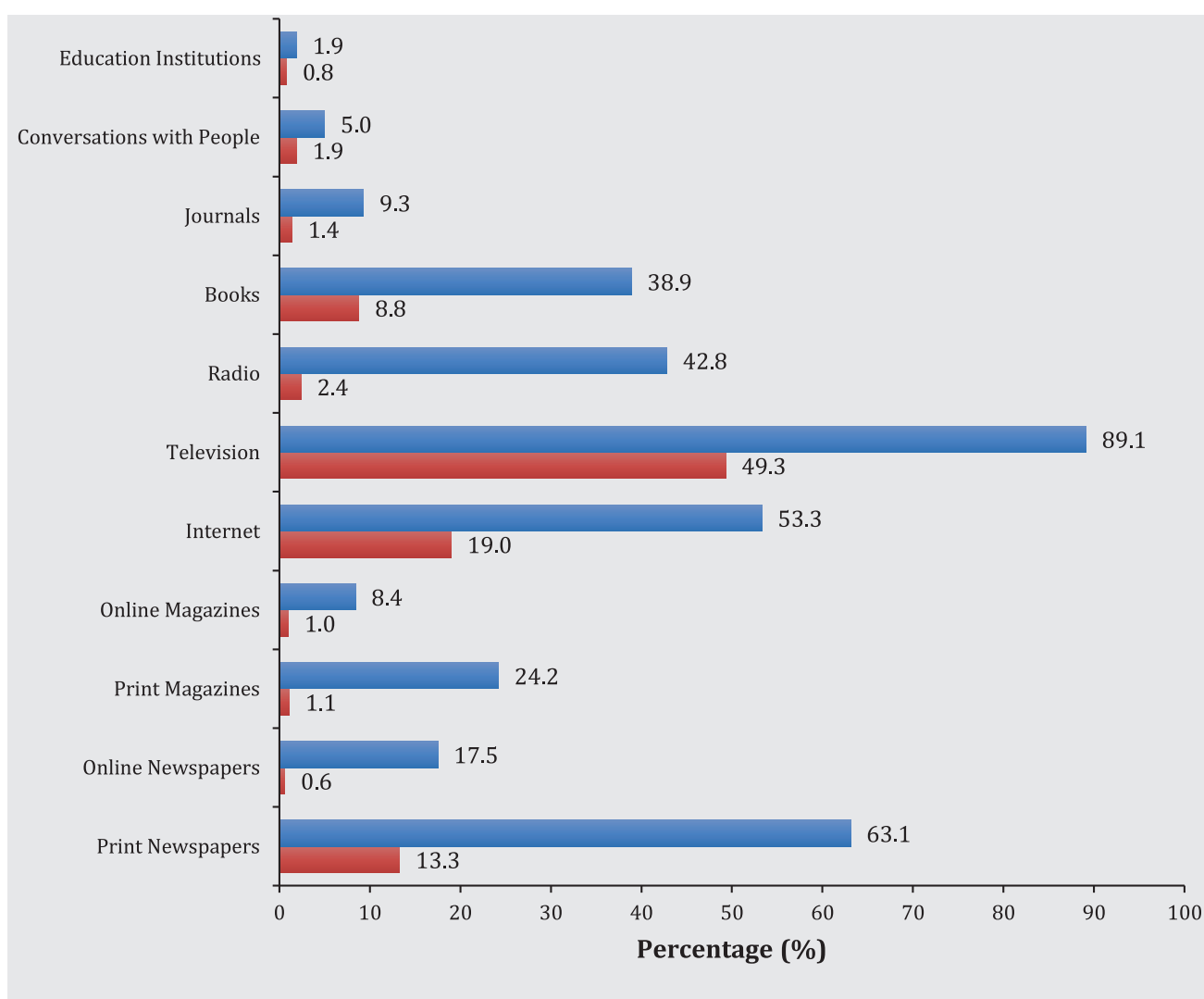
Over the years from 1998 – 2014, the main source of information among Malaysians was television, followed by newspaper and radio (Table 3.5). There has been a declining percentage of respondents obtaining their information from magazines since 2000. In 2014, it is clear that the Internet (65.2%) had overtaken magazines (51.3%) as a more popular choice of information source (Table 3.5). Malaysians using the Internet as a source of information reaches over 50% for the first time in 2014. The Internet as a source of information has been gaining popularity since 2008, most likely due to the ease of access from electronic devices with increasingly affordable internet access packages.

Table 3.5 Sources of Information, 1998 – 2014

Sources	1998	2000	2002	2004	2008	2014
Newspapers	92.6	93.2	89.9	84.2	62.1	86.7
Magazines	81.0	82.3	64.2	63.8	22.1	51.3
Television	97.6	97.7	98.4	97.2	82.4	97.3
Radio	82.5	88.1	85.3	78.1	32.1	77.5
Internet	22.1	40.2	43.9	34.4	24.8	65.2

Source : Public Awareness of STI Malaysia 2014

The most popular choice of information source on STI issues is also television (89.1%, Figure 3.7). This trend has been consistent over the years. This is followed by print newspapers (63.1%), the Internet (53.3%) and radio (42.8%). The respondents indicate that television (49.3%) is the most reliable source of information for STI, followed by the Internet (19.0%), print newspapers (13.3%) and books (8.8%).

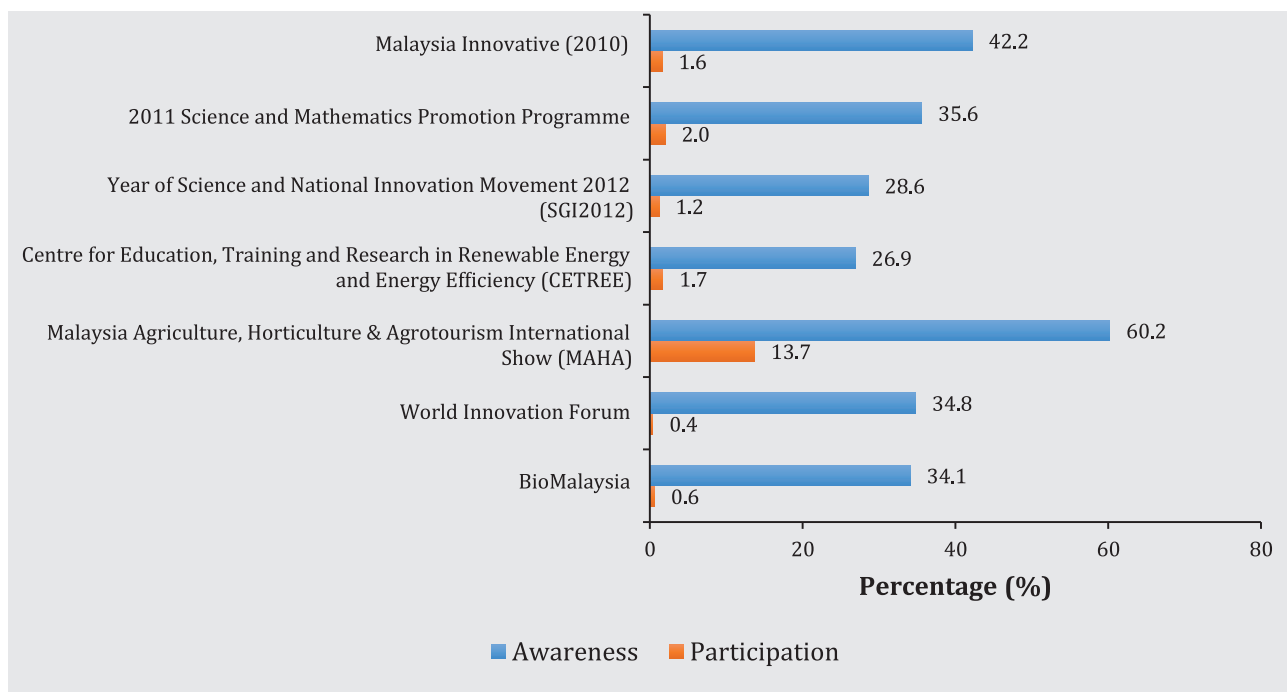
Figure 3.7 Information Sources on STI and Reliability, 2014

Source : Public Awareness of STI Malaysia 2014

3.6 Public Awareness of Government STI Programmes and Policies

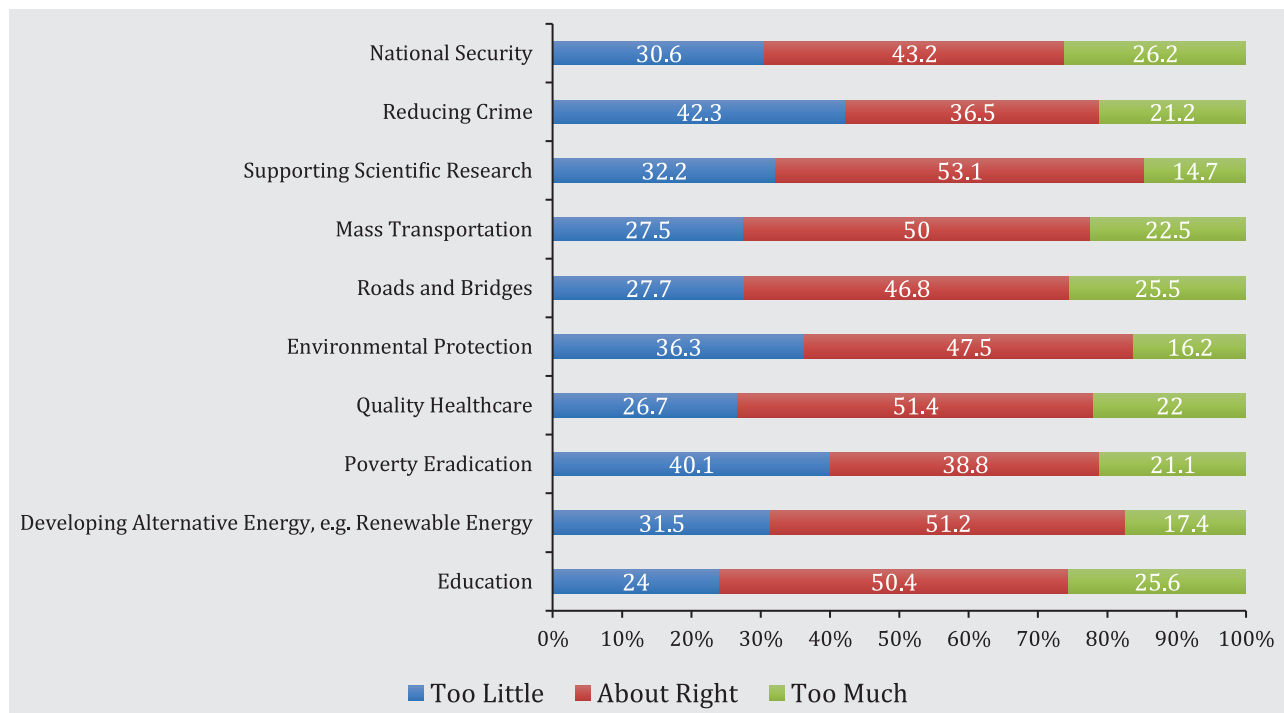
More than one third of the respondents have heard of several STI related government programmes – such as the Malaysia Agriculture, Horticulture & Agrotourism International Show (MAHA) (60.2%), Malaysia Innovative 2010 (42.2%) and 2011 Science and Mathematics Promotion Programme (35.6%). However, the public participation in these programmes is relatively low, with most programmes having less than 2.0% respondent participation (Figure 3.8).

Figure 3.8 Awareness and Participation in Government STI Programmes, 2014



Source : Public Awareness of STI Malaysia 2014

Generally, the public thinks that the government is spending too little – particularly on reducing crime (42.3%) and eradicating poverty (40.1%), as shown in Figure 3.9. In contrast, slightly more than half of the respondents think that the government is spending just about the right amount on supporting scientific research (53.1%) and developing alternative energy sources, such as renewable energy (51.2%).

Figure 3.9 Public Assessment on Government Spending, 2014

Source : Public Awareness of STI Malaysia 2014

3.7 International Comparison

This section describes the comparison of Malaysian public interest and knowledge of STI as well as public attitudes towards STI against that of other countries. In addition, it compares the main sources of information on STI issues and the public opinion on government spending for certain areas.

3.7.1 Public Interest in STI

Generally, lower percentages of respondents in Malaysia are very interested in the STI issues compared to the USA and EU (Table 3.6). Nevertheless, the combined average percentages of respondents from Malaysia who are either interested or very interested in the issues (78%) is close to that of the USA (89%) and the EU (83%). This indicates that the Malaysian public is generally interested in the STI issues, but they are not as passionate as the respondents from the USA and EU.

Table 3.6 Respondents' Interest Level in STI Issues by Countries (%)

Selected Issues	Malaysia 2014			USA 2014			EU 2014		
	Very Interested	Interested	Not Interested	Very Interested	Interested	Not Interested	Very Interested	Interested	Not Interested
The use of new inventions and technologies	23	61	13	42	46	11	n.a.	n.a.	n.a.
New medical discoveries	17	62	18	58	36	5	32	50	17
Environmental pollution	16	57	25	45	45	9	37	51	11
New scientific discoveries	12	63	21	40	45	14	30	49	20
Average percentage	17	61	19	46	43	10	33	50	16

Note : n.a. = not available

Source : Public Awareness of STI Malaysia 2014; National Science Board (2014) *Science and Engineering Indicators 2014*; European Commission (2010) *Special Eurobarometer 340: Science and Technology*

Table 3.7 Responses on Scientific Concepts and Statements by Countries (%)

Scientific Terms and Concepts	Malaysia 2008	Malaysia 2014	USA 2014	China 2010	EU 2005	India 2004	Japan 2011	Russia 2003	South Korea 2004
The earth travels around the sun	73	85	74	n.a.	66	70	n.a.	n.a.	86
The centre of the earth is very hot	66	75	84	56	86	57	84	n.a.	87
The continents have been moving their location for millions of years and will continue to move	44	62	83	50	87	32	88	40	87
It is the father's gene that determines the gender of the baby	40	45	63	58	64	38	29	22	59
Electrons are smaller than atoms	33	35	53	27	46	30	32	44	46
Lasers work by focusing sound waves	16	30	47	23	47	n.a.	32	24	31
All radioactivity is man-made	14	20	72	48	59	n.a.	69	35	48
Antibiotics kill viruses as well as bacteria	8	16	51	28	46	39	33	18	30
Average percentage of questions answered correctly	37	46	66	41	63	44	52	31	59

Note : n.a. = not available

Source : Public Awareness of STI Malaysia 2014; National Science Board (2014) *Science and Engineering Indicators 2014*

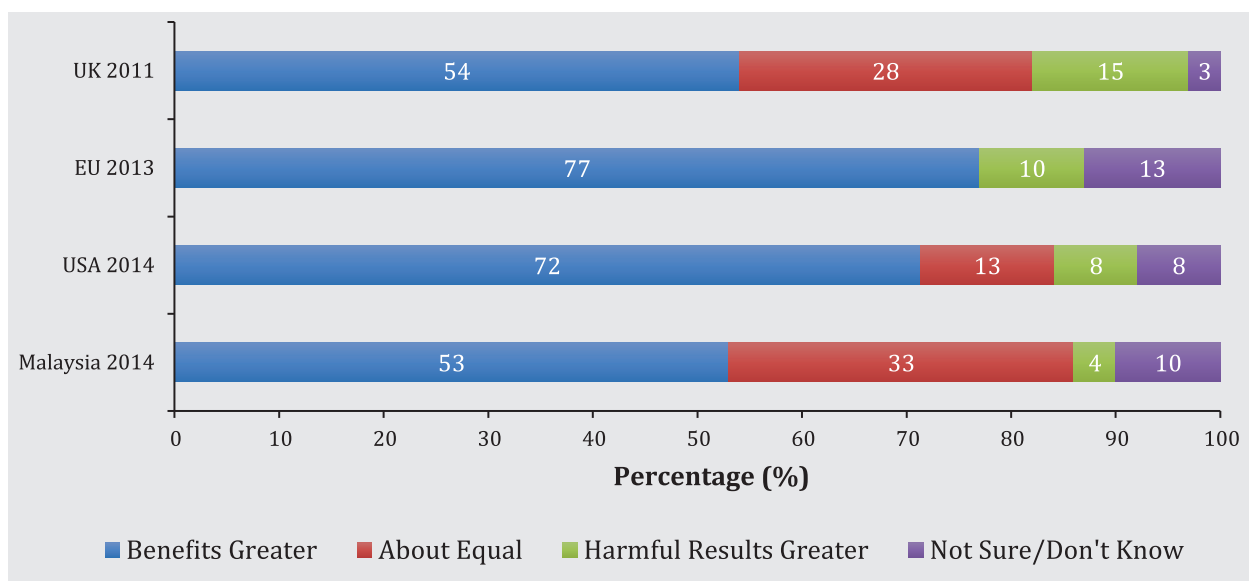
3.7.2 Public Knowledge of STI Issues

On average, although there was an improvement from 37% in 2008 to 46% in 2014, Malaysia's public knowledge on STI issues is behind the more advanced nations such as the USA, EU, South Korea and Japan (Table 3.7). There are more than twice the number of respondents from these nations than from Malaysia who are able to answer correctly for more specific questions such as "all radioactivity is man-made" and "antibiotics kill viruses as well as bacteria".

3.7.3 Public Attitudes towards STI

Similar to the percentage of respondents from the United Kingdom (UK: 54%), slightly more than half of the Malaysian respondents (53%) perceive that scientific research brings greater benefits than harm (Figure 3.10). Nevertheless, the percentage is still behind that for the USA (72%) and EU (77%), where almost three quarters of the respondents perceive greater benefits from scientific research.

Figure 3.10 Public Assessment of Scientific Research by Selected Countries



Source : Public Awareness of STI Malaysia 2014; National Science Board (2014) *Science and Engineering Indicators 2014*

Respondents from Malaysia clearly agree that STI improves the quality of their lives (92%), recording a higher percentage compared to the EU (66%) and the UK (79%). Also, as high as 95% of Malaysians agree that STI is very important for the progress of the nation, compared to 87% and 75% in the USA and EU respectively (Table 3.8). However, a majority of respondents from Malaysia (81%) and the EU (62%) agree that science has caused their lifestyles to change too fast, against slightly less than half of the respondents from the USA (42%). Although there is similar percentage of respondents in the USA (42%), EU (39%) and Malaysia (42%) agreeing with the statement "we depend too much on science and not enough on faith", there is a higher percentage from Malaysia disagreeing (58%) compared to the USA (30%) and EU (32%).

Table 3.8 Public Attitudes toward Science and Technology by Countries (%)

Statements	Malaysia 2014		USA 2014		EU 2013		UK 2011	
	Agree	Disagree	Agree	Disagree	Agree	Disagree	Agree	Disagree
We depend too much on science and not enough on faith	42	58	42	30	39	32	n.a.	n.a.
Science causes our lifestyles to change too fast	81	19	42	56	62	18	n.a.	n.a.
STI improves the quality of our lives	92	8	n.a.	n.a.	66	9	79	5
STI is very important for the progress of our nation	95	5	87	10	75	7	n.a.	n.a.

Note : n.a. = not available

Source : Public Awareness of STI Malaysia 2014; National Science Board (2014) *Science and Engineering Indicators 2014*

3.7.4 Information Sources on STI

Television is the main source of information on STI issues in Malaysia, similar to the EU (65%), UK (54%) and Taiwan (95%). The Internet (42%) is the top source of STI information for the USA, followed by television (32%). In Malaysia, the Internet is gaining popularity as a source of information and is currently the third most popular choice of STI information source (Table 3.9).

Table 3.9 Responses on Information Sources for STI by Selected Countries (%)

Information Sources on STI	Malaysia 2014	EU 2013	UK 2011 (maximum 2 answers)	Taiwan 2012	USA 2014 (single answer)
Newspapers	63	33	33	58	7
Magazines	24	n.a.	9	49	8
Internet	53	35	19	53	42
Television	89	65	54	95	32
Radio	43	17	14	15	2
Books	39	14	8	31	3

Note : n.a. = not available

Source : Public Awareness of STI Malaysia 2014; European Commission (2010) *Special Eurobarometer 401: Responsible Research and Innovation*; Ipsos MORI (2011) *Public Attitudes towards Science 2011*; National University of Sun Yat-Sen, Centre of General Education (2012) *Survey of Scientific Literacy Taiwan 2012*; National Science Board (2014) *Science and Engineering Indicators 2014*

3.7.5 Public Awareness of Government STI Programmes and Policies

Most of the USA's respondents (75%) think that their government is spending too little on education, while most Malaysians (50%) think that the spending is about the right amount. A relatively high percentage of the USA and Malaysia respondents think that the government is spending too little on reducing crime and eradicating poverty (Table 3.10). On the other hand, most respondents from the USA (60%) and Taiwan (44%) think that the government is spending too little on developing alternative energy, while most Malaysians (51%) think that the government is spending just about the right amount.

Table 3.10 Responses on Government Spending by Selected Countries (%)

Matters	Malaysia 2014			USA 2014			Taiwan 2012		
	Too Little	About Right	Too Much	Too Little	About Right	Too Much	Too Little	About Right	Too Much
Education	24	50	26	75	18	7	41	41	2
Developing Alternative Energy, e.g. Renewable Energy	32	51	17	60	28	7	44	38	1
Poverty Eradication	40	39	21	61	26	10	40	46	1
Quality Healthcare	27	51	22	61	23	14	34	50	3
Environmental Protection	36	48	16	58	30	10	n.a.	n.a.	n.a.
Roads and Bridges	28	47	26	43	43	12	n.a.	n.a.	n.a.
Mass Transportation	28	50	23	38	46	10	n.a.	n.a.	n.a.
Supporting Scientific Research	32	53	15	38	45	12	22	38	2
Reducing Crime	42	37	21	52	36	9	n.a.	n.a.	n.a.
National Security	31	43	26	24	40	32	15	39	20

Note : Taiwan's data does not add up to 100% since the "Don't Know" responses were not included; n.a. = not available

Source : Public Awareness of STI Malaysia 2014; National Science Board (2014) *Science and Engineering Indicators 2014*; National University of Sun Yat-Sen, Centre of General Education (2012) *Survey of Scientific Literacy Taiwan 2012*

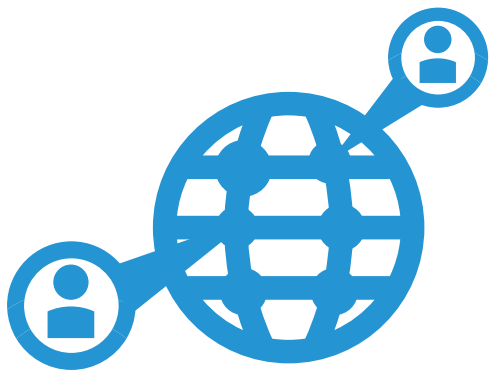
3.8 Summary

Malaysians were found to be slightly to moderately interested in science and technology in 2008. However, in 2014 Malaysian public awareness improved, as Malaysians indicated that they are either interested or very interested in the STI issues. Of these STI issues, Malaysians are most interested in the use of new inventions and technologies. Nevertheless, the percentage of Malaysians who are very interested in selected STI issues is much lower in comparison to the USA and EU. The national public awareness surveys also indicate that there is a declining interest in environmental pollution issues among Malaysians over the years 1998 – 2014, which may be a concern. The government has to take steps to arrest the decline, such as conducting various programmes addressing environmental issues as well as STI issues in general. The national surveys also reveal that the level of education is positively related to the level of interest in STI issues.

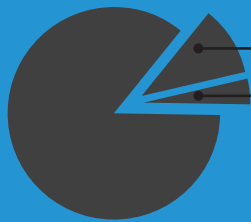
Public knowledge of STI among Malaysians generally has been decreasing since 1998, although there is an improvement from 2008 to 2014. Over the past 16 years, the average public knowledge of STI in Malaysia has been below 50%. Malaysian public knowledge on STI is lacking, particularly concerning statements or concepts on specialised STI topics such as “antibiotics kill viruses as well as bacteria”. Although Malaysian public knowledge on STI issues in 2014 has improved compared to 2008, Malaysia is still behind developed countries such as the USA, EU, South Korea and Japan.

Malaysians generally have a positive attitude towards scientific research and STI. More than half of Malaysians perceive that scientific research brings greater benefits than harm, similar to respondents from the UK but less than the USA and the EU. Malaysians mostly perceived positive effects of STI on public healthcare, followed by working conditions and lifestyle. There is an increasing percentage of respondents perceiving positive effects of STI on the environment and cost of living, but a decreasing percentage for positive effects on working conditions. The 2014 survey also found that 88.7% of the respondents were willing to change their lifestyle in order to reduce emissions and climate change impacts, while 60.5% were opposed or strongly opposed to the use of nuclear power to generate electricity in Malaysia. Television is the main source of information among Malaysians, followed by newspapers and radio. Television is also the main source of information on STI issues among Malaysians, the same choice as respondents from the EU, UK and Taiwan. On the other hand, the Internet is the top source of STI information in the USA, and is recently gaining popularity as a source of information in Malaysia – especially as a source of information on STI issues.

More than one third of the Malaysian respondents are aware of STI related government programmes, but the participation by them is relatively low at below 2.0%. The government will need to focus efforts in encouraging active participation from relevant parties in the STI related programmes. On the matter of government spending, Malaysian respondents think that the government is spending just about the right amount on supporting scientific research and developing alternative energy, but too little on reducing crime and eradicating poverty. A high percentage of the USA’s respondents also share the same sentiment that the government is spending too little in reducing crime and eradicating poverty.



Information and Communication Technology

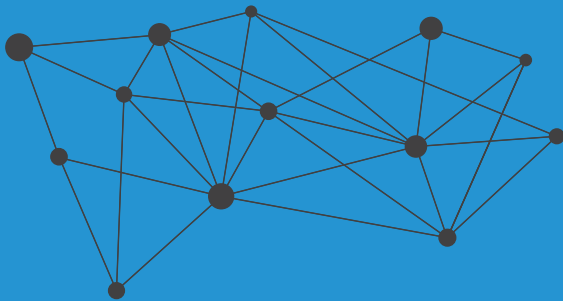


ICT industry
E-commerce

ICT industry has contributed
about 17%
to GDP in 2014.

RM208.3 billion

in exports with trade surplus of RM48.8 billion in 2014.



Cellular telephone penetration has reached

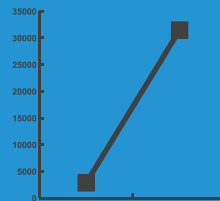
above 100

per 100 inhabitants since 2010, attained
148.3 in 2014 and 143.8 in 2015.



The total employment contribution of the ICT
industry is:

1.04 million



Increasing trend in terms of the number of
hotspot locations in Malaysia. The number
increased from 2,846 in 2009 to 31,493 in
2012, over a period of 3 years, an increase of

11 times.



Broadband penetration
rate has improved
from 55.6% per 100
households in 2010 to

77.3%

in 2015.

...the first of these is the fact that the ...

...the second of these is the fact that the ...

...the third of these is the fact that the ...

...the fourth of these is the fact that the ...

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CHAPTER 4: INFORMATION AND COMMUNICATION TECHNOLOGY

4.1 Introduction

Information and Communication Technology (ICT) has long been identified as a significant enabler of science, technology, and economic and business development. It is estimated that in 2014, ICT industries contributed about 17% (12.4% from ICT industry and 4.6% from E-commerce) to the Malaysian economy, with RM208.3 billion in exports and RM159.5 billion in imports. The total employment contribution of the industry is estimated to be 1.04 million jobs¹⁰.

Malaysia has witnessed upgrading of advanced ICT infrastructure since the launch of the MSC project and establishment of institutions to propagate ICT (in terms of both content and technologies). The establishment of institutions led to rapid diffusion of ICT in Malaysia¹¹. Institutions and governing agencies were also established to execute ICT-related policies and regulatory framework for ICT related activities. This chapter provides insight into progress and development of the ICT sector in Malaysia. Specifically, the chapter highlights the consumption and demand of ICT to reflect the usage trends of ICT services and related products; as well as the funding for R&D activities to reflect the commitment to research, technological innovation and development. This chapter also provides information on the production in ICT to reflect the industrial capabilities in performing production and trading of ICT related goods; and workforce in ICT to reflect the services and skills demanded for ICT industrial upgrading and development.

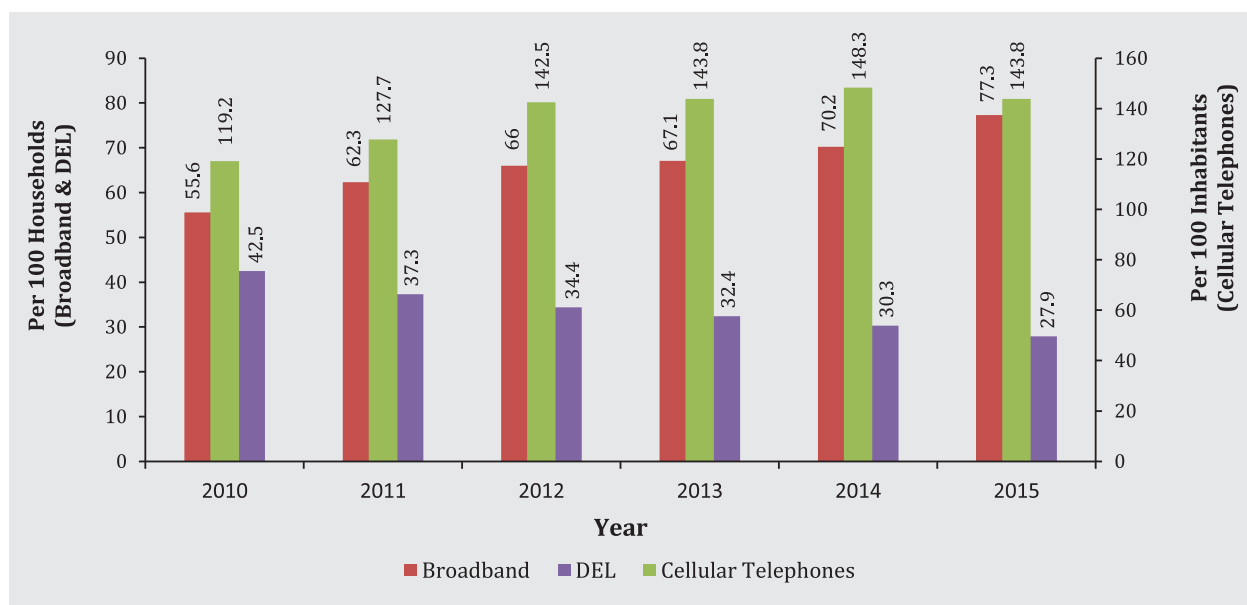
4.2 ICT Access and Infrastructure

The basic indicators to reflect the use of ICT are the penetration rates for cellular telephones, broadband and direct exchange lines (DEL). Figure 4.1 shows the penetration rates for cellular telephones, broadband and DEL in terms of per 100 households. The penetration rate for broadband has increased sharply, from 55.6 per 100 households in 2010, to 77.3 in 2015. This can be attributed to the increasing popularity of broadband as a medium to interact and exchange information. The population seems to find such a medium of communication effective, enabling them to exchange relatively large amounts of data or information in their daily communications. The increase of cellular penetration has reached above 100 per 100 inhabitants since 2010, attaining 148.3 in 2014 and 143.8 in 2015. This reflects a significant portion of the population owning multiple cellular telephones. The penetration of cellular telephones seems to have substituted the penetration of DEL. The penetration rate for DEL has decreased from 42.5 per 100 households in 2010 to 27.9 in 2015.

¹⁰ See ICT Satellite Account 2010 – 2014, Department of Statistics, Malaysia. Estimation for 2014.

¹¹ See Wong, C-Y., Chandran, VGR and Ng, B-K. (2016).

Figure 4.1 Penetration Rate for Different Types of ICT Devices, 2010 - 2015



Source : Malaysian Communications and Multimedia Commission Pocketbook of Statistics

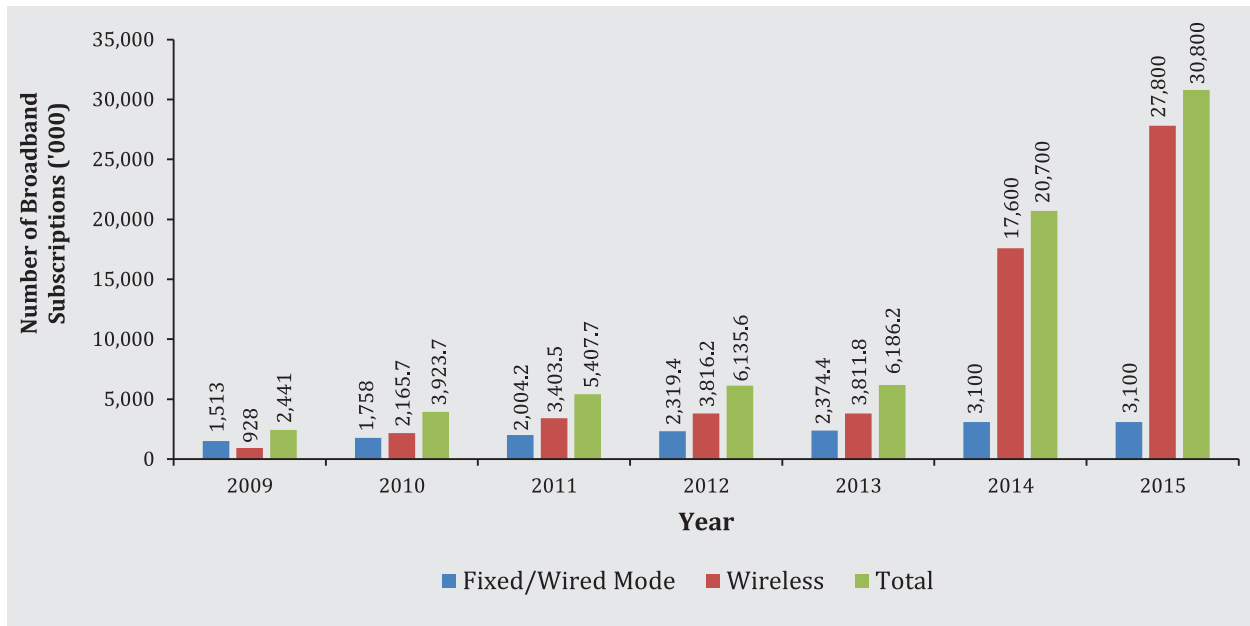
Note : Figure for 2015 refers to Q4 2015.

4.2.1 Mode of Broadband Internet Access in Malaysia

Malaysia witnessed a sharp increase in broadband subscriptions during the period between 2009 and 2012. Fixed/wired mode was the preferred mode of internet access of many in Malaysia in 2009, higher than for wireless mode (Figure 4.2). Wireless subscriptions had overtaken the fixed/wired mode in 2010. The growth for both modes then stabilised. Malaysia attained only a marginal growth for both modes between 2012 and 2014. Malaysian STI Indicators 2013 reported that social networking, search and navigation of information, photo sharing, and use of multimedia and blogs are the top usages of the Internet among Malaysians.

Figure 4.3 shows the percentage of broadband penetration rates per 100 households by state, comparing 2010 and 2015. Overall, in Malaysia, the broadband penetration rate has increased from 55.6% per 100 households in 2010 to 77.3% in 2015. There is a rather mixed outcome over this period of development. While many states witnessed a significant improvement for their broadband penetration rates, certain states saw a contraction of broadband penetration rate. Negeri Sembilan, Perlis, Pulau Pinang and Kuala Lumpur have witnessed contraction in their broadband penetration growth rate over the period of 2010 and 2015. Nevertheless, the overall household broadband penetration is increasing over the years.

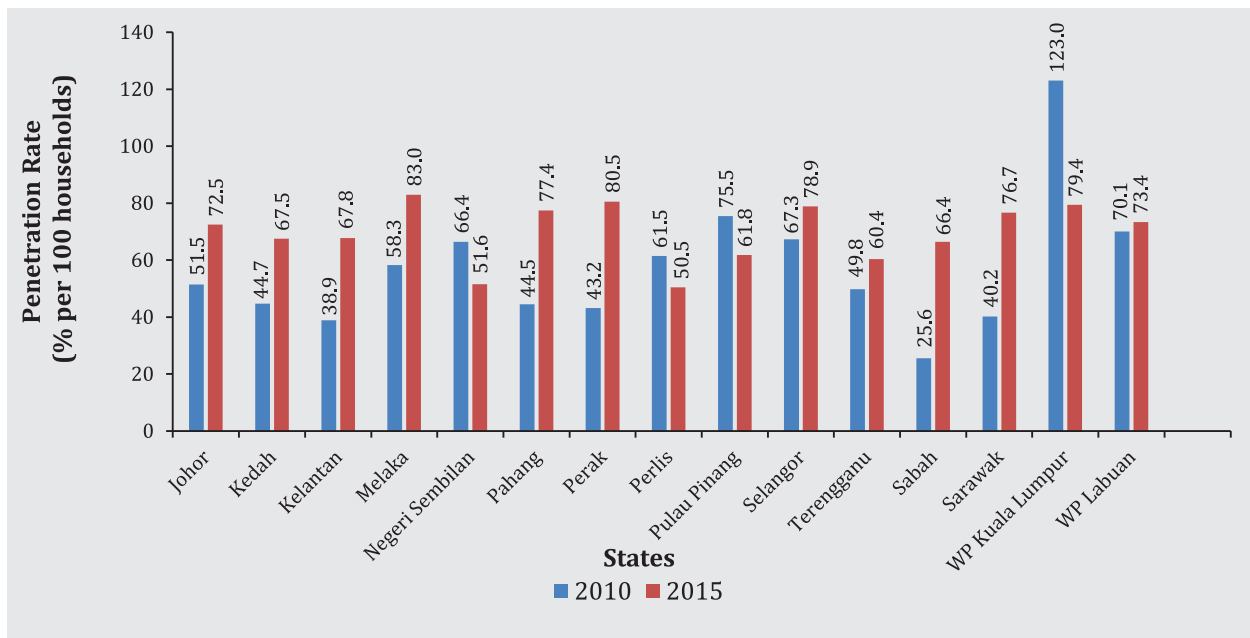
Figure 4.2 Modes of Broadband Internet Access in Malaysia, 2009 - 2015



Note : Numbers are rounded up to million for 2014 and 2015.

Source : Malaysian Communications and Multimedia Commission Pocketbook of Statistics

Figure 4.3 Broadband Penetration Rates by State, 2010 and 2015

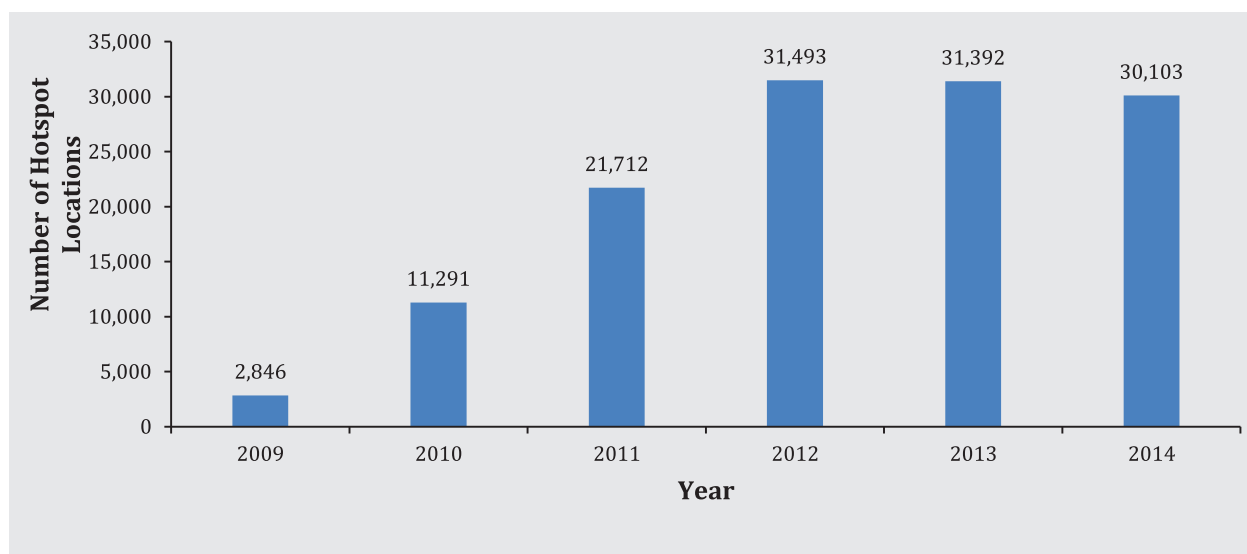


Note : Figures for 2015 only covers until quarter 3 of 2015. "The broadband penetration rate per 100 households is calculated by dividing the number of subscriptions used in private households by the number of private households and multiplying by 100." Non-private household subscriptions and public WiFi subscriptions are not taken into account.

Source : Malaysian Communications and Multimedia Commission Pocketbook of Statistics

There is an increasing trend in terms of the number of hotspot locations in Malaysia (Figure 4.4). The number increased from 2,846 in 2009 to 31,493 in 2012, an increase of 11 times over a period of 3 years. It then stabilised, witnessing a slight decrease since 2013. Table 4.1 provides the statistics for number of hotspot locations in Malaysia for 2013 and 2014. There are nearly 30,000 hotspot locations in Malaysia with the most highly concentrated in the more developed states.

Figure 4.4 Number of Hotspot Locations in Malaysia, 2009 – 2014



Source : Malaysian Communications and Multimedia Commission Pocketbook of Statistics

Table 4.1 Number of Hotspot Locations by State

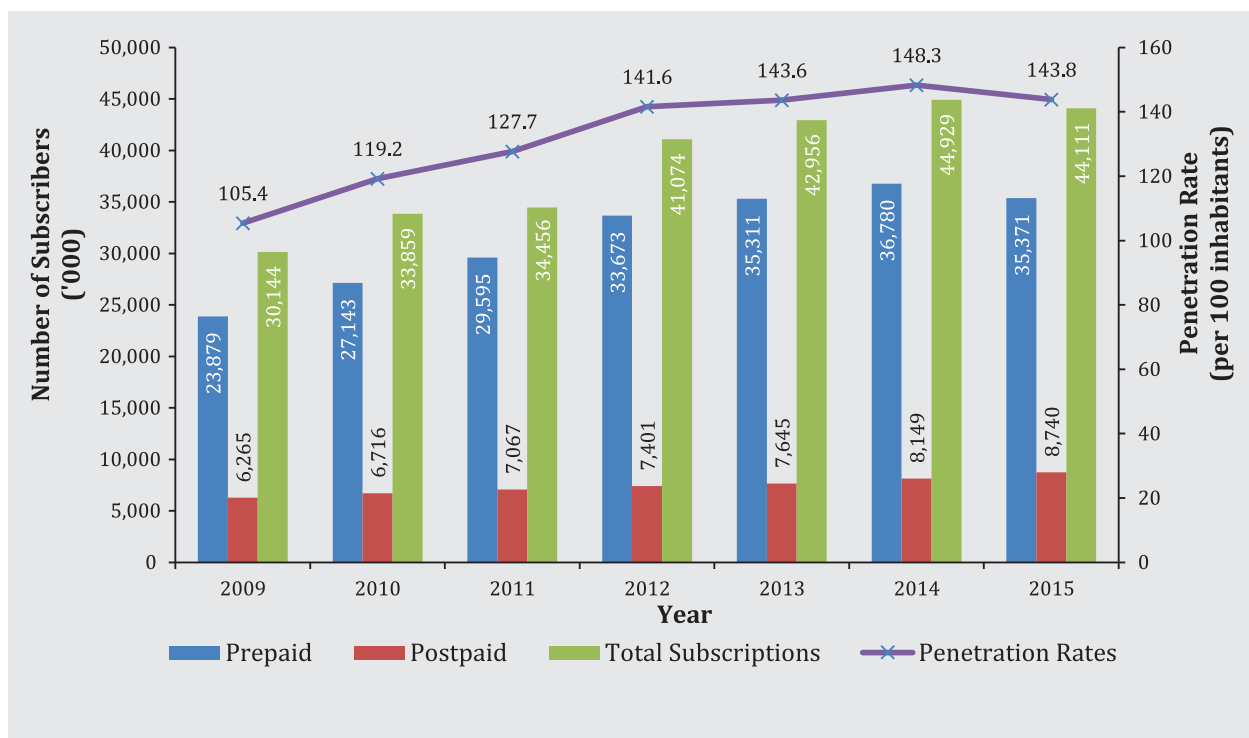
State	2013	2014
Johor	3,052	3,039
Kedah	2,304	2,212
Kelantan	1,115	1,112
Melaka	1,262	1,255
Negeri Sembilan	553	645
Pahang	1,462	1,448
Perak	1,933	1,875
Perlis	62	62
Pulau Pinang	5,283	4,494
Selangor	5,058	4,895
Terengganu	1,464	1,458
Sabah	956	954
Sarawak	1,896	1,889
WP Kuala Lumpur	4,935	4,709
WP Labuan	6	6
WP Putrajaya	51	50
Malaysia	31,392	30,103

Source : Malaysian Communications and Multimedia Commission Pocketbook of Statistics

4.2.2 Cellular Telephones and DEL in Malaysia

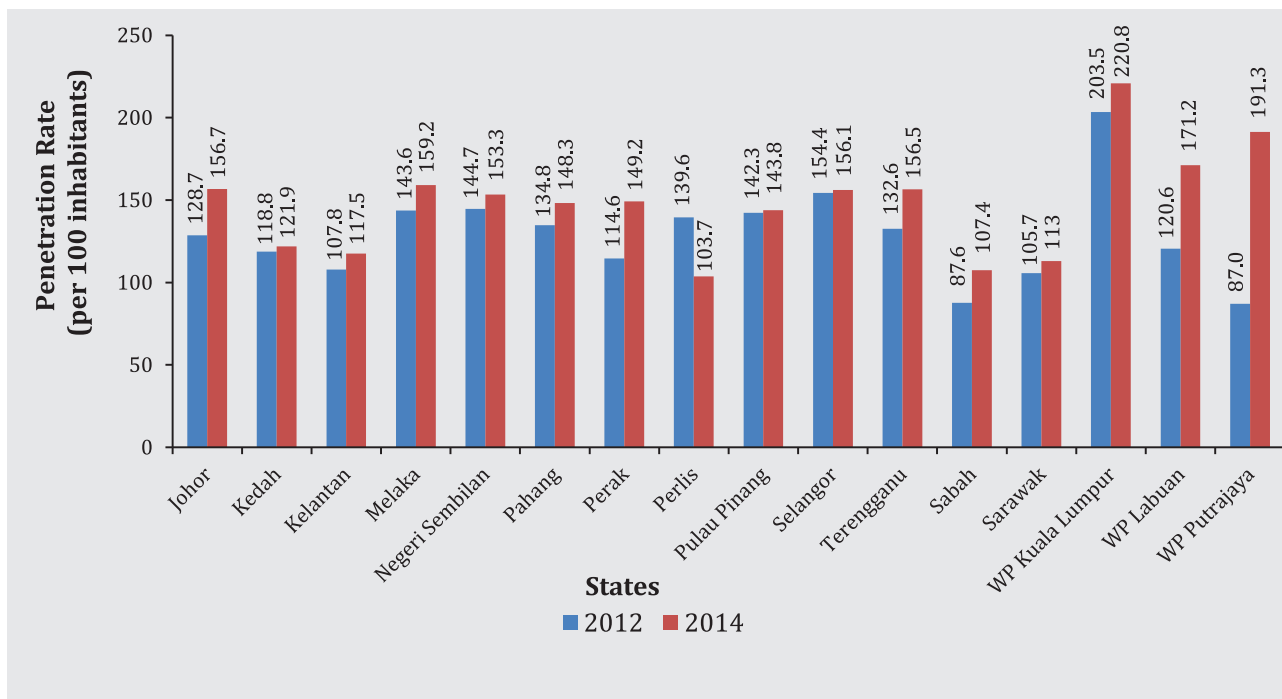
Figure 4.5 shows the subscriptions of cellular telephones in Malaysia. The penetration rate of cellular telephones reached a breakpoint of 100 per 100 inhabitants in 2009, implying affordability of the technology to the general public of Malaysia. By 2014, the penetration rate of cellular telephones had reached 148.3 per 100 inhabitants. Malaysia witnessed a slight contraction in 2015. Prepaid mode emerged to dominate the subscription mode, contributing about 80 percent of the total cellular telephone subscriptions. Postpaid mode on the other hand witnessed marginal increase since 2009. Figure 4.6 shows the cellular telephone penetration rate per 100 inhabitants by state. There are many states in Malaysia which attained the breakpoint of above 100 in terms of per 100 inhabitants. This can be attributed to the rapid urbanisation and economic development of the respective states. Perlis is the only state that witnessed contraction in its cellular telephone penetration rate between 2012 and 2014. The use of short message services (SMS) has been declining since 2010 (Figure 4.7). The number of SMS per subscription from 2010 to Q2 2015 showed a sharp contracting trend, from 2,859 in 2010 to 585 in 2015. This can be attributed to the substitution phenomenon from SMS to free texting services through mobile applications. The preference for adopting mobile telecommunication and the increasing use of broadband for internet have led to a decline of direct exchange lines (DEL). By 2015, the penetration rate for DEL was 27.9 per 100 households, compared with 42.5 per 100 households in 2010 (Figure 4.8).

Figure 4.5 Cellular Telephone Subscriptions and Penetration Rates in Malaysia



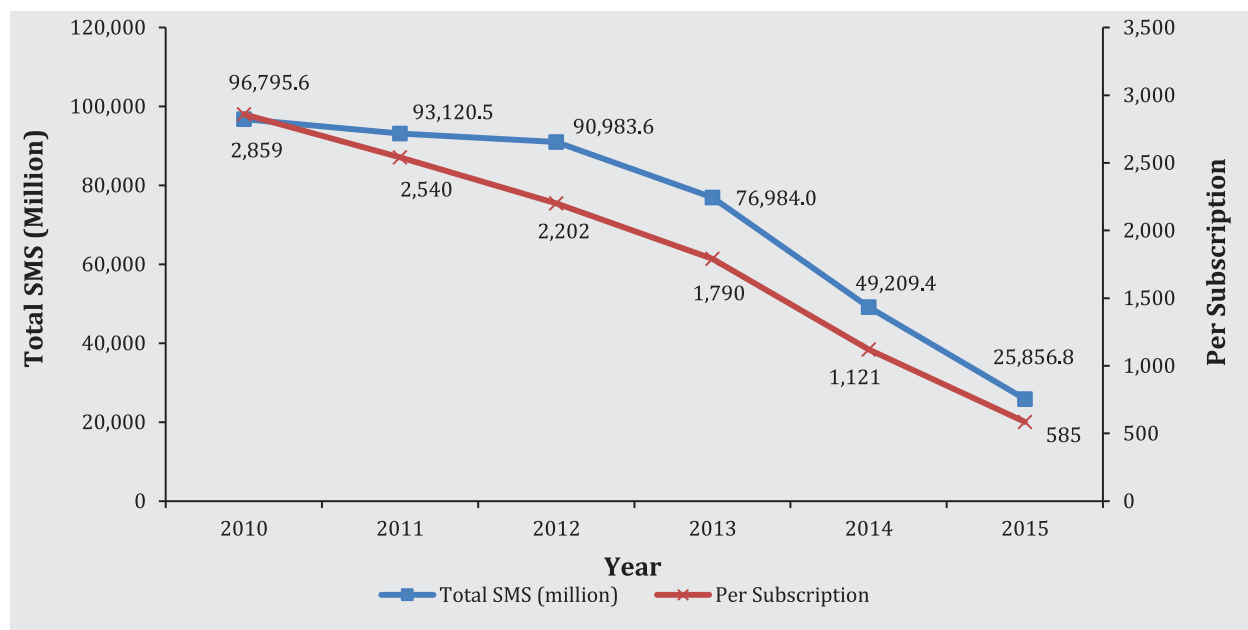
Source : Malaysian Communications and Multimedia Commission Pocketbook of Statistics

Figure 4.6 Cellular Telephone Penetration Rate by State, 2012 and 2014

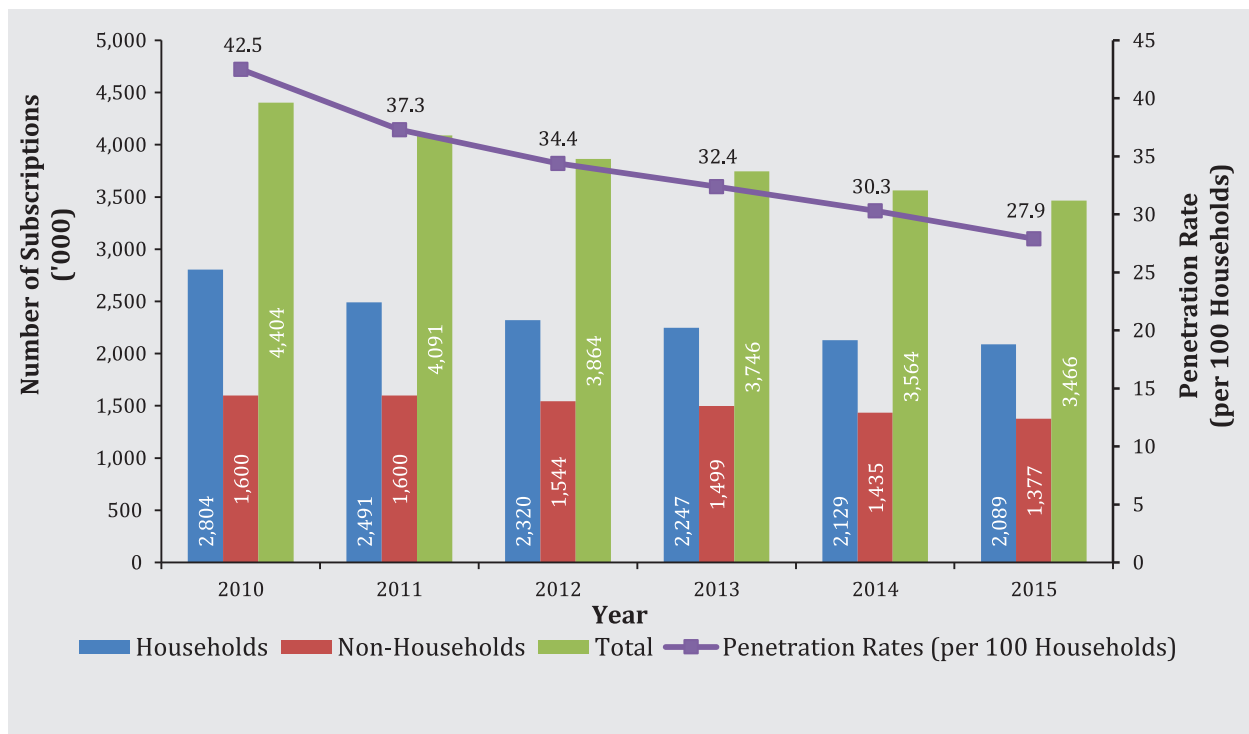


Source : Malaysian Communications and Multimedia Commission Pocketbook of Statistics

Figure 4.7 SMS Usage in Malaysia, 2010 - 2015



Source : Malaysian Communications and Multimedia Commission Pocketbook of Statistics

Figure 4.8 Direct Exchange Lines in Malaysia, 2010 – 2015

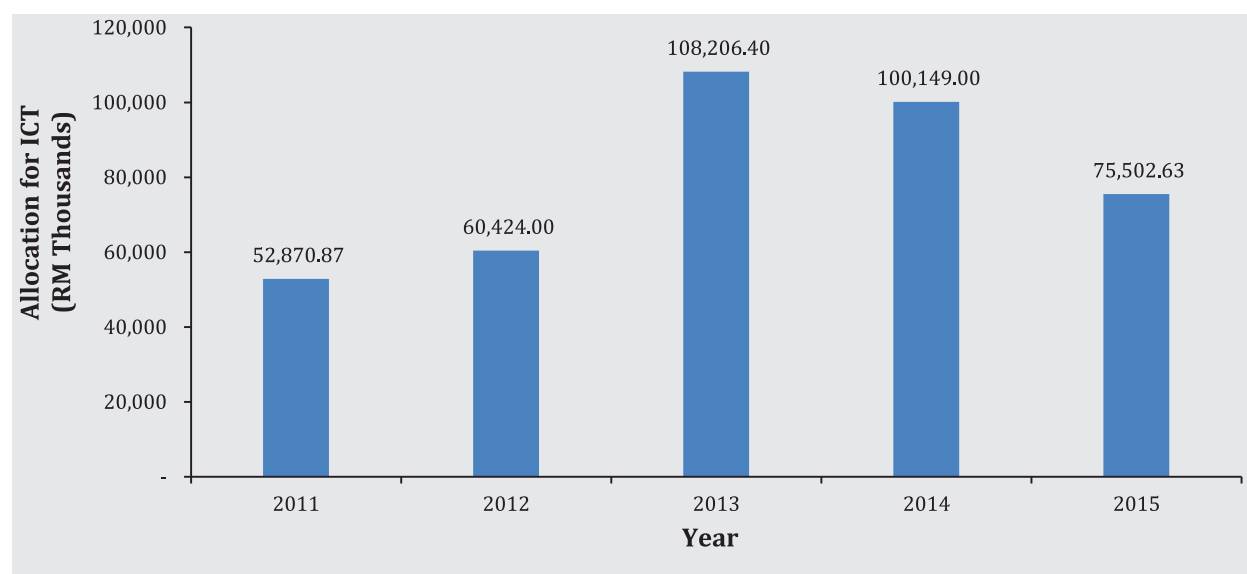
Source : Malaysian Communications and Multimedia Commission Pocketbook of Statistics

4.3 ICT Funding and Support

There are a few ICT areas being identified as the digital opportunities for technological ventures in the 11th Malaysia Plan. The so called millennials generation can venture into miniaturisation of devices/wearable technology, cloud computing, cognisant computing, big data and E/M-commerce. Malaysia's 2012 ICT roadmap charted emerging technological areas that would contribute to socio economic development. The six emerging areas are E-services, wireless intelligence, ubiquitous connectivity, security and platforms, big data/analytics and cloud computing. These areas are being considered as the convergence technologies derived from areas that were identified as emerging in the 2008 ICT roadmap. These include wireless sensor networks, predictive analytics and 3D internet¹².

Figure 4.9 shows the funding allocation for the ICT Policy Division (MOSTI), MIMOS Berhad and CyberSecurity Malaysia during the 10th Malaysia Plan. It is noteworthy that there is a substantial increase of allocation in 2013. The subsequent allocation for 2014 contracted to about RM100 million. It contracted further in 2015 to about RM75.5 million. This study observes that there is a considerable share of allocation committed to public research activities.

¹² See PIKOM ICT Strategic Review 2015/2016.

Figure 4.9 Funding Allocation for Selected Projects, 2011 – 2015

Source : Development Division, MOSTI

There was considerable funding for ICT related research, development and commercialisation activities during the period of the 10th Malaysia Plan (Table 4.2). The total amount approved was RM36.6 million for scientific related projects under ScienceFund, with a slightly lower amount (RM30.5 million) being approved for technological, development and commercialisation related projects under TechnoFund, and RM7.83 million being approved for projects under InnoFund. InnoFund is the scheme to fund development or improvement of new or existing products, processes or services.

Table 4.2 Funding Approval for ICT Cluster

Year	Amount Approved (RM)		
	ScienceFund	TechnoFund	InnoFund
2011	9,876,377	4,934,150	4,101,772
2012	11,620,898	4,060,903	1,834,000
2013	7,794,283	15,763,059	286,365
2014	3,802,528	4,253,000	840,165
2015*	3,550,890	5,295,135	769,000
Total	36,644,976	34,306,247	7,831,302

Note : *As of 31 Dec 2015

Source : ICT Policy Division, MOSTI

While there was substantial allocation and grants devoted to advanced ICT-research related activities of Malaysia, there was a contraction of MSC grants and funds in two different periods of time (Table 4.3). The total approved and disbursed funds of the MSC Malaysia R&D Grant Scheme (MGS) and Product Development and Commercialisation Fund (PCF) were much higher during the period of the 9th Malaysia Plan. The total grants approved under the 9th Malaysia Plan was RM100.5 million, while only RM28.8 million was approved during the period of the 10th Malaysia Plan. The total grants disbursed under the 9th Malaysia Plan was RM91.5 million, while only RM12.18 million (42.2%) was disbursed during the period

of the 10th Malaysia Plan. MSC R&D expenditure was consistent during the period of the 10th Malaysia Plan (2010 – 2014). There was RM1.64 billion committed for MSC R&D in 2010, RM1.59 billion in 2011, RM1.64 billion in 2012, RM1.4 billion (being the lowest) in 2013, and RM1.67 billion in 2014¹³.

Table 4.3 Total Approvals and Disbursements of MSC Grants

Periods	Total Project Approvals (MGS)	Total Grants Approved (RM)	Total Grants Disbursed (RM)
9 th MP	70	100,554,159.00	91,524,547
	Total Project Approvals (MGS/PCF)	Total Grants Approved (RM)	Total Grants Disbursed (RM)
10 th MP*	22	28,820,446.00	12,184,594.00

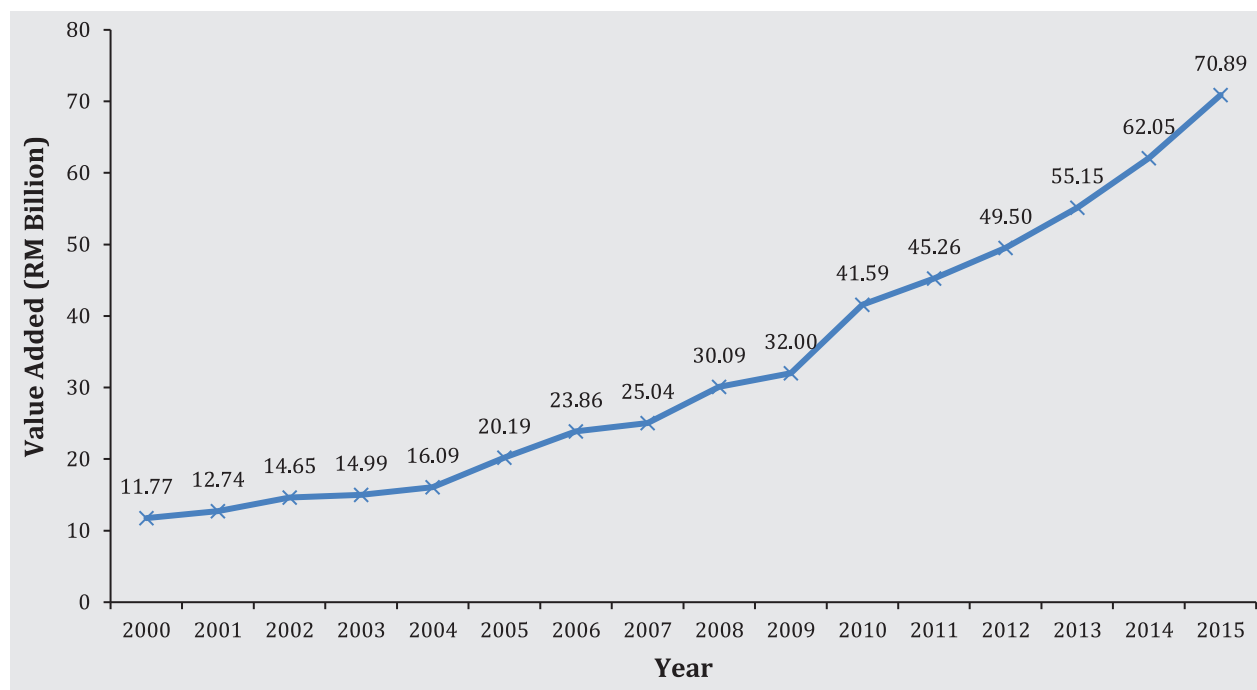
Note : *As of 31 December 2015

Source : MDEC

4.4 ICT Industry Value Added, Trade and Employment

Malaysia witnessed tremendous value added growth in ICT industrial outputs since 2000 (Figure 4.10). It is noteworthy that there was a significant increase in value added activities in 2010, increasing from RM32.00 billion in 2009 to RM41.59 billion in 2010. In 2015, ICT industries contributed RM70.89 billion in value added activities.

Figure 4.10 Value Added of ICT Industry in Malaysia, 2000 – 2015

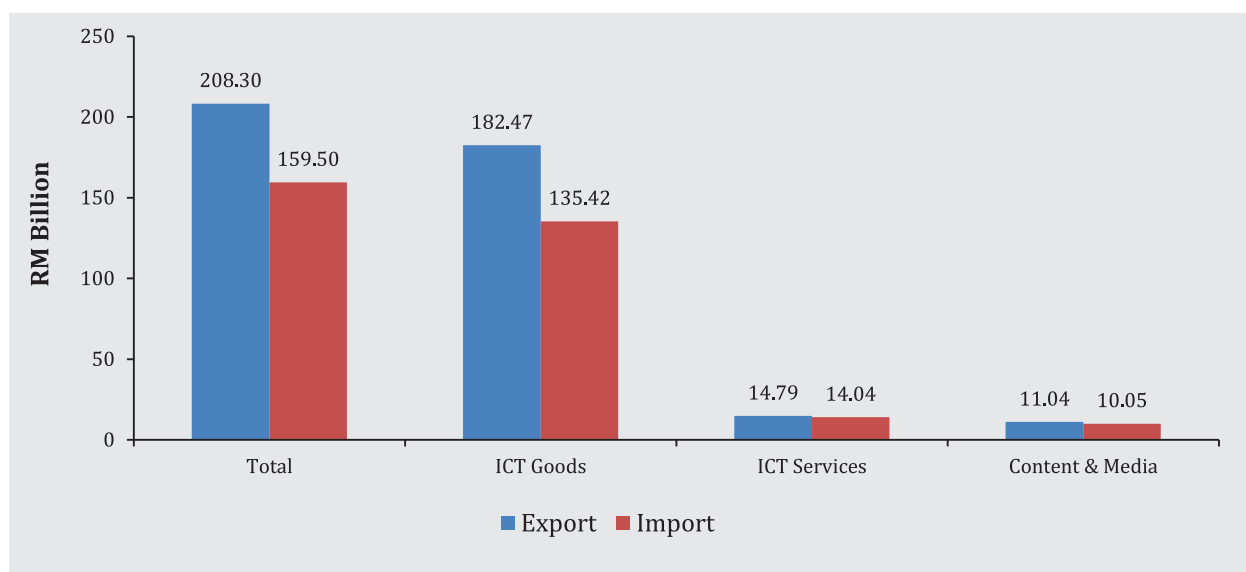


Source : PIKOM Job Market Outlook

¹³ See MSC Malaysia Annual Industry Report 2014.

It is noteworthy that much of the ICT trading is attributable to import and export of ICT goods (Figure 4.11). The total exports and imports of ICT are worth RM208.3 billion and RM159.5 billion respectively. There was RM182.47 billion worth in export of ICT goods in 2014. Malaysia imported RM135.42 billion worth of ICT goods, and gained a positive trade balance of RM47.05 billion. ICT services and content and media products seem to have gained momentum in ICT industrial activities, having a trade surplus. Nonetheless, the activities have yet to attain the level of ICT goods.

Figure 4.11 Import and Export of ICT Products of Malaysia, 2014



Source : Department of Statistics, Malaysia (2010 – 2014), ICT Satellite Account

The MSC program of Malaysia is seen as the catalyst of growth for the ICT industry in Malaysia. It has led to a significant number of companies established in Malaysia, and this in turn creates jobs and professions that build niches in the ICT production value chain. It is reported that there is a total of RM38.52 billion in terms of MSC revenue, an increase of about 36% from 2010¹⁴. Much of the sales were gained from the local market, while the export market contributed about 36% of the MSC sales in 2014. There were 3,632 MSC status companies in 2014, an increase of 30% compared to 2009 (Table 4.4). There were about 75% of MSC companies in 2014 owned by local entrepreneurs. 147,568 jobs were created in 2014 by MSC companies, where 54% of these were created from the locally owned companies.

Table 4.5 shows the employment figures of ICT industries. Manufacturing emerged as the dominant industry that offers the most employment opportunities in the ICT labour market of Malaysia, contributing about 39% to 42% of the total employment annually. ICT services stands out as the second most performing industry in terms of employment, contributing about 27% to 29% annually to the total employment figures for ICT. ICT trade and content and media industries have shown progressive employment trends over the period of analysis.

¹⁴ See MSC Malaysia Annual Industry Report 2014.

Table 4.4 Total MSC Status Companies and Jobs Created (Cumulative)

Year	MSC Malaysia Companies		Foreign Owned Companies		Locally Owned Companies	
	Number	Jobs Created	Number	Jobs Created	Number	Jobs Created
2009	2,520	99,590	566	33,547	1,954	66,043
2010	2,738	111,536	608	42,113	2,130	69,254
2011	2,954	119,138	650	46,662	2,304	72,476
2012	3,167	128,850	714	66,021	2,453	62,829
2013	3,403	138,071	832	60,629	2,329	77,442
2014	3,632	147,568	897	67,588	2,735	79,980

Source : STI Indicators Report 2013; MSC Malaysia Annual Industry Report 2014

Table 4.5 Employment in the ICT Industry, 2010 – 2014

Sector	Number of Persons ('000)				
	2010	2011	2012	2013*	2014**
ICT Manufacturing	401	409	393	406	413
ICT Trade	166	157	162	195	190
ICT Services	261	278	293	277	291
Content and Media	129	141	148	140	147
Total ICT Employment	957	985	995	1,018	1,041
Total Employment in Malaysia*	11,900	12,284	12,723	13,210	13,532

Note : *Estimates; ** Preliminary data

Source : Department of Statistics Malaysia (2010 – 2014), ICT Satellite Account

Malaysia exhibits strength in two skill categories, namely “Software & Application Development” and “OS & Server Technologies”. There are many ICT personnel who have been trained with these skills. This can be attributed to the high demand for these ICT personnel in servicing sectors in Malaysia. In addition, the growth in some other advanced skill categories is probably due to increasing demand for highly skilled personnel, as Malaysia’s firms are investing in knowledge-oriented activities and transforming their businesses to perform more high value added operations and services. This is evident in the number and compound annual growth rate (CAGR) of Malaysian ICT employees in “Networking & Security”, “Business Intelligence & Analytics”, “Enterprise Resource Planning (ERP)” and “Creative Multimedia” (Table 4.6).

Table 4.6 ICT Employment by Skill Categories in Malaysia, 2014 – 2017

Skills Category	ICT Employees (Number)				CAGR (%)
	2014	2015	2016	2017	
Software & Application Development	210,596	213,755	216,961	220,215	1.5
Networking & Security	43,753	45,066	46,418	47,810	3
Database	89,743	90,641	91,547	92,463	1
OS & Server Technologies	166,218	166,218	166,218	166,218	0
Business Intelligence & Analytics	19,098	19,862	20,656	21,482	4
ERP	23,461	24,047	24,648	25,264	2.5
Hardware Design & Embedded Systems	17,093	17,349	17,610	17,874	1.5
HR Management	64,468	64,791	65,115	65,440	0.5
Finance	57,808	57,808	57,808	57,808	0
Creative Multimedia	72,538	74,352	76,211	78,116	2.5

Note : Figures for 2016 and 2017 are based on estimations.

Source : Extrapolated from MSC Malaysia Talent Supply-Demand Study 2014-2017

While the advancement of ICT in Malaysia is evident in this chapter, there are also incidents that affect cyber security. Based on data collected from the Malaysia Computer Emergency Response Team (MyCERT), spam and fraud cases are the most common incidents that affected the security of the cyber world for the period between 2011 and 2015. Nonetheless, it is noteworthy that the total number of incidents has been reduced from 15,218 in 2011 to 9,915 in 2015 (Table 4.7).

Table 4.7 Cyber Security Incidents, 2011 – 2015

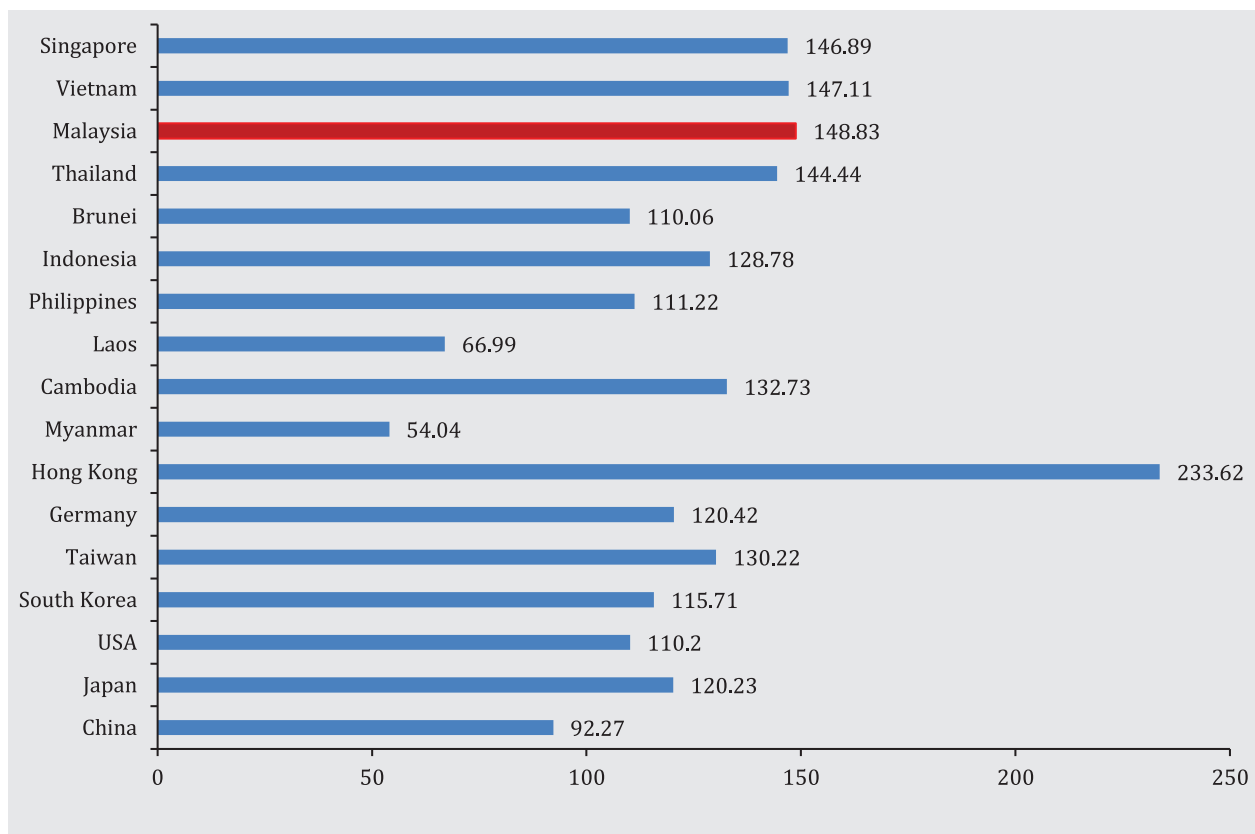
Incident	2011	%	2012	%	2013	%	2014	%	2015	%
Content Related	59	0.39	20	0.2	54	0.51	35	0.29	33	0.33
Cyber Harassment	459	3.02	300	3	512	4.81	550	4.61	442	4.46
Denial of Service	78	0.51	23	0.23	19	0.18	29	0.24	38	0.38
Fraud	5,328	35.01	4,001	40.07	4,485	42.17	4,477	37.57	3,257	32.84
Intrusion	3,699	24.31	4,326	43.32	2,770	26.04	1,125	9.44	1,714	17.29
Intrusion Attempt	734	4.82	67	0.67	76	0.71	1,302	10.92	303	3.06
Malicious Codes	1,012	6.65	645	6.46	1,751	16.46	716	6.01	567	5.72
Spam	3,751	24.65	526	5.27	950	8.93	3,650	30.63	3,539	35.69
Vulnerabilities Report	98	0.64	78	0.78	19	0.18	34	0.29	22	0.22
Total	15,218	100	9,986	100	10,636	100	11,918	100	9,915	100

Source : www.mycert.org.my/statistics/2015.php

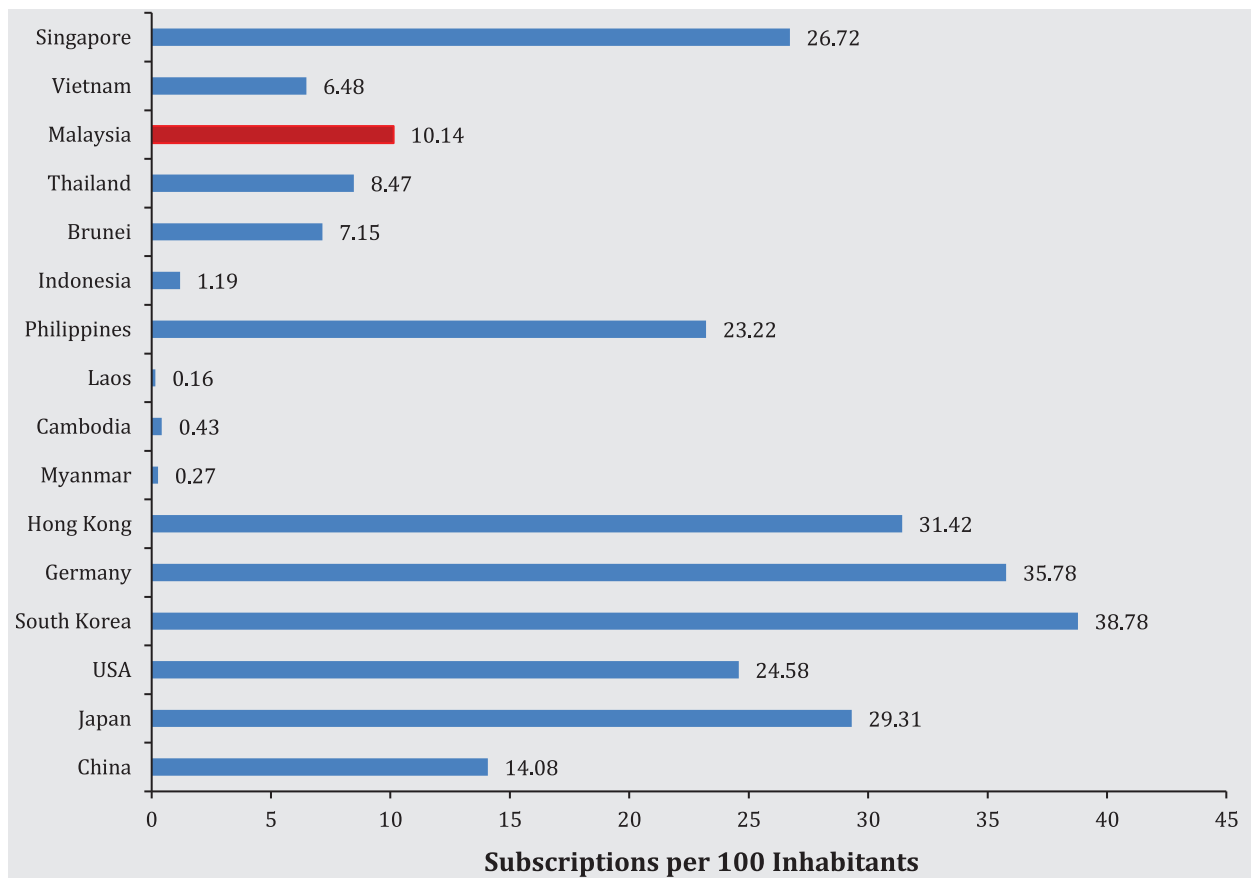
4.5 International Comparison

Figure 4.12 and Figure 4.13 compare Malaysia's performance in cellular telephone and fixed broadband subscriptions per 100 inhabitants with those of selected countries. In terms of cellular telephone penetration rate, Malaysia attained a level comparable to many advanced countries in the world. Indeed, there are other emerging countries in Southeast Asia such as Vietnam and Thailand performing at level comparable to that of the advanced countries. Other Southeast Asian countries such as Brunei, Indonesia, the Philippines and Cambodia have had commendable performances in their respective cellular telephone penetration rates. Hong Kong emerged as an economy that attained a relatively high level of cellular telephone subscriptions per 100 inhabitants. For fixed broadband subscriptions, advanced economies such as Hong Kong, Germany and South Korea are leading the way compared to the developing countries (Figure 4.13). Among Southeast Asian countries, the Philippines stands out as a country that attained a high level of subscriptions, comparable to that of Singapore. While Malaysia performs at a level above many countries in Southeast Asia, it lacks behind many advanced countries in the world.

Figure 4.12 Mobile Telephone Subscriptions per 100 Inhabitants of Selected Countries, 2014



Source : International Telecommunication Union (ITU)

Figure 4.13 Fixed Broadband Subscriptions of Selected Countries, 2014

Source : International Telecommunication Union (ITU)

4.6 Summary

This chapter highlighted the progress of ICT development in terms of the use of ICT services and related products, commitment to research, technological innovation and development, and capability in performing production and trading of ICT related goods and services. The performance Malaysia attained for the use of ICT services and related products is commendable. Its performance in terms of diffusion rate of cellular telephones is comparable to that of the advanced countries of the world. Nonetheless, the commitment to ensure systematic establishment of broadband infrastructure and policy to make broadband technology accessible and affordable remain crucial for ICT development.

The commitment toward research, innovation and technology development is evident in this chapter. The rapid growth of ICT outputs, the increase of MSC status companies, ICT job creation and strength of particular skills in ICT can be attributed to the commitment toward R&D and innovation. It is important to ensure the commitment for ICT development remains, as it would contribute to both the use and capability of producing ICT services and related products.



R&D Investment and Research Workforce



R&D Expenditure, 2014

GERD

RM13,972 million

GERD/GDP = 1.26%



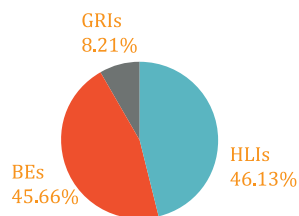
Top 3 FORs by GERD:

- ICT
- Engineering and Technology
- Natural Sciences

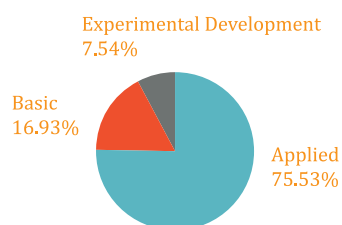
Top 3 SEOs by GERD:

- Sustainable Economic Development
- Advanced Experimental and Applied Science
- Society

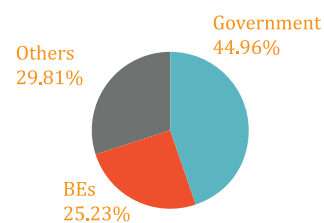
GERD by sectors:



GERD by research types:



Sources of funds:



▶▶ CHAPTER 5



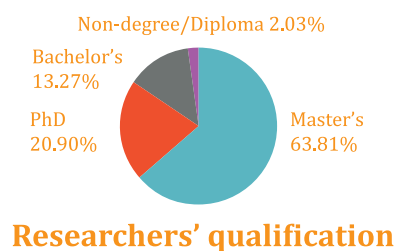
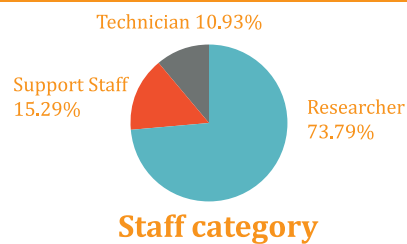
Research Workforce, 2014

Total R&D personnel
114,539

Researchers in 10,000 workforce
60.66

FTE of R&D personnel
75,062

% of female researchers
48.78%



International Comparison, 2014

(Benchmarking Malaysia with the group of 40 top performing economies, data from IMD CWY and UNESCO Institute for Statistics)

- GERD = 29th
- GERD/GDP = 31st
- BERD/GDP = 33rd
- FTE/1,000 people = 40th
- % of female researchers = 16th



CHAPTER 5: R&D INVESTMENT AND RESEARCH WORKFORCE

5.1 Introduction

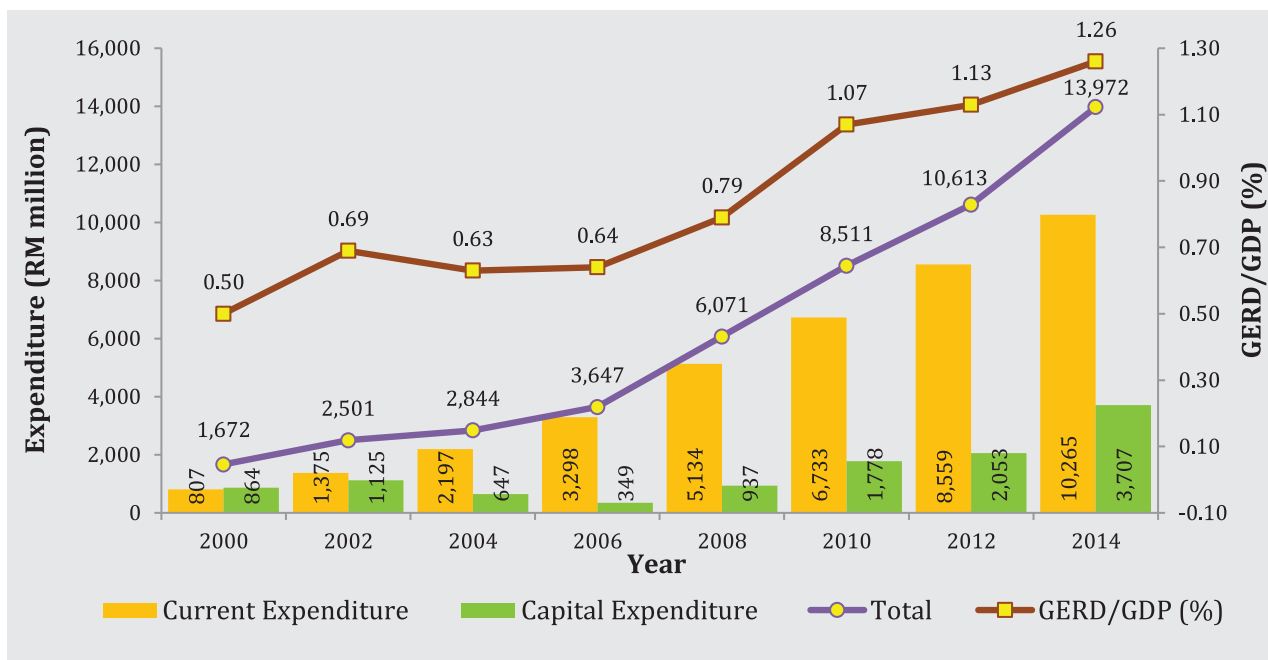
R&D plays a critical role in a nation's technological capabilities development efforts. It leverages S&T to address national challenges, and introduces into the market new technologies in products, processes and services – which help promote economic growth. National R&D investment is one of the inputs that nurtures and develops these new technologies. For business enterprises, firms utilising R&D investment show better performance in building and sustaining competitive advantages. In addition, the success of R&D goes hand-in-hand with other driving factors within the National Innovation System. The availability of a diverse, vibrant and sustainable R&D workforce that is capable of driving R&D activities in the longer term has been accepted as one of the key factors that complements R&D investment.

This chapter presents an overview of the status of R&D activities and workforce during the period of 2000 – 2014. It provides insights on R&D activities among Malaysia's Business Enterprises (BEs), Higher Learning Institutions (HLIs), and Government Agencies and Research Institutes (GRIs). It also highlights Malaysia's R&D progress over the years with respect to gross expenditure on R&D (GERD), GERD by Field of Research (FOR) and Socio-Economic Objectives (SEOs), types of R&D activities, sources of funding, as well as several other key indicators that indicate the quantity and quality of the R&D workforce in Malaysia – such as researcher headcount and qualification. An international benchmarking is undertaken to shed light on the status of Malaysia's R&D investment and workforce in comparison to selected economies.

5.2 Gross Expenditure on R&D

GERD is the national total gross expenditure on R&D in a given period. It measures both current (such as labour and operating costs) and capital expenditures (such as land, buildings and other structures, vehicles, plants, software, machinery and equipment) related to R&D activities. Likewise, GERD measured as a percentage of Gross Domestic Product (GDP) represents a nation's degree of R&D intensity, a common indicator for international comparisons. Malaysia's GERD reached RM13,972 million in 2014 which was the best performance since 2000 (Figure 5.1). In fact, this nearly five-fold growth in GERD during the last ten years (i.e. 2004 – 2014) was impressive. Corresponding to the positive growth in GERD, the R&D intensity as represented by the percentage of GERD over GDP stood at 1.26% in 2014. This indicates a more than two-fold increase over the year 2000. About 73.45% of the R&D expenditure was classified as current expenditure. The current expenditure increased twelve-fold, from RM807 million in 2000 to RM10,265 million in 2014. Likewise, the capital expenditure grew over four-fold, from RM864 million in 2000 to RM3,707 million in 2014.

Figure 5.1 Gross Expenditure on R&D, 2000 – 2014



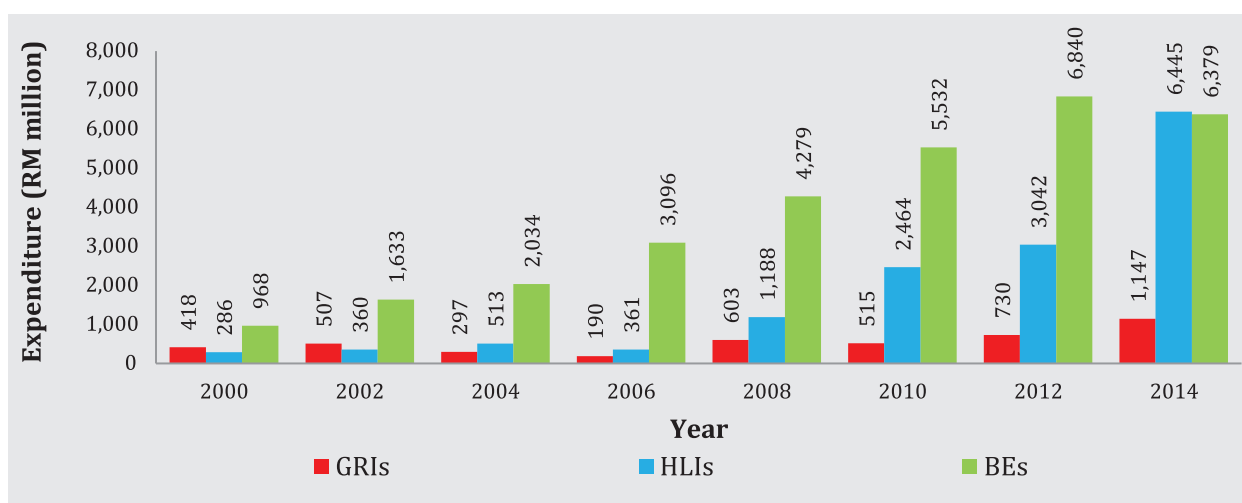
Source : National Survey of R&D in Malaysia 2013, 2015

5.3 R&D Expenditure by Sector

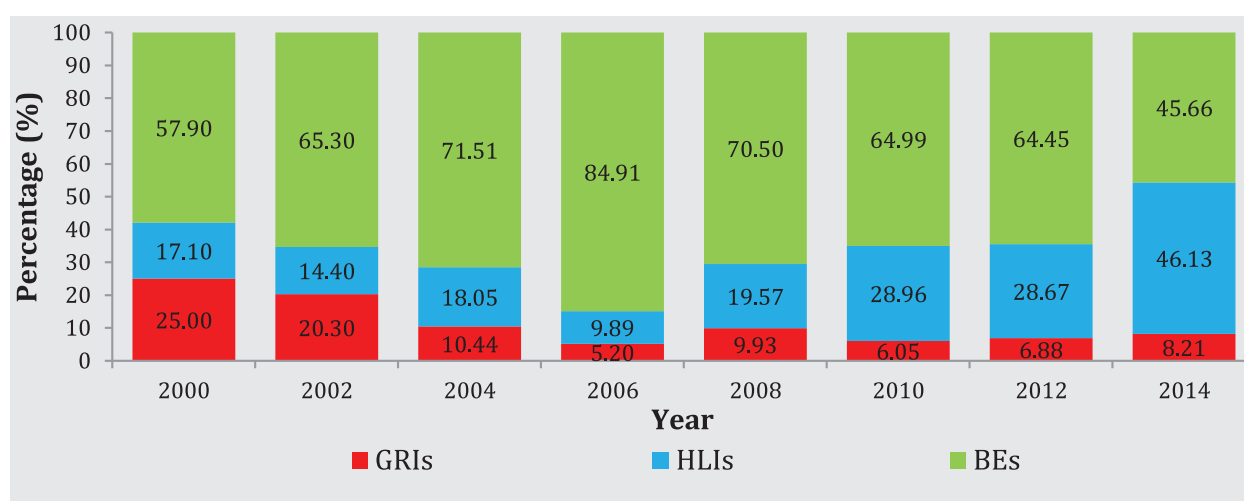
Figure 5.2 shows the GERD contribution by main sectors, namely HLIs, GRIs and BEs over the period of 2000 – 2014. Although BEs was the major contributor to GERD, the amount of R&D expenditure decreased by about RM461 million or 6.74% during 2012 – 2014. This downward trend does not match the country’s agenda in developing BEs – particularly the Small and Medium-sized Enterprises (SMEs) – as a main innovation driver of the NKEA¹⁵. HLI contribution to GERD doubled from RM3,042 million to RM6,445 million, and as a result, in 2014 it surpassed BEs as the main contributor to GERD for the first time over the period of 2000 – 2014. Meanwhile, GRI contribution also doubled, albeit at a smaller percentage over the last four years 2008 – 2014.

Observing the GERD by sectors for 2000 – 2014 shows the limited presence of BEs in national R&D activities (Figure 5.3). In 2006, BEs contributed 84.9% to the GERD, which was its best performance. Since then, the performance of BEs has declined. BEs contribution fell from 57.9% in 2000 to 45.7% in 2014. In contrast, HLIs contribution surged sharply from 17.1% in 2000 to 46.1% in 2014. The major drop in BEs’ GERD in 2014 was partly balanced by an increase in government funding, which can be witnessed through the drastic surge in HLIs R&D expenditure.

¹⁵ The National Survey of R&D 2015 report suggests two plausible explanations for the decline in BE performance. Firstly, the small number of BE respondents in 2014 might lead to the under-reporting of the actual BERD. Secondly, several institutions previously classified as BEs in 2012 have been reclassified as GRIs, namely: Sarawak Biodiversity Centre; Astronautic Technology Sdn. Bhd.; and CRAUN Research Sdn. Bhd.

Figure 5.2 GERD by Sector Comparison, 2000 – 2014

Source : National Survey of R&D in Malaysia 2013, 2015

Figure 5.3 GERD by Sector, 2000 – 2014

Source : National Survey of R&D in Malaysia 2013, 2015

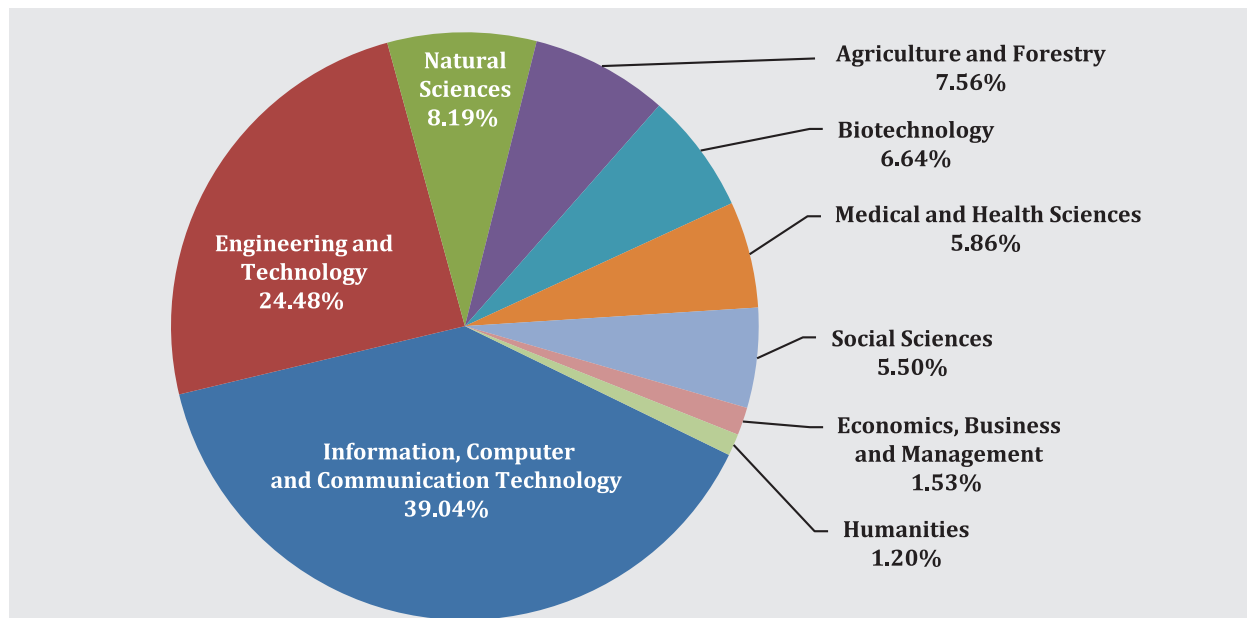
5.4 Expenditure by Type of Activity

5.4.1 R&D Expenditure by FOR

R&D expenditure by Field of Research (FOR) indicates that Information, Computer and Communication Technology is the major field accounting for 39.04% of the GERD, followed by Engineering and Technology, and Natural Sciences, with 24.48% and 8.19% respectively (Figure 5.4). Agriculture and Forestry, Biotechnology, Medical and Health Sciences, and Social Sciences have contributed in the range of 5% to 6%, while Economics, Business and Management, and Humanities each have contributed less than 2%. There was a remarkable increase in the share of Information, Computer and Communication Technology between 2012 and 2014, increasing from 10.79% in 2012 to 39.04% in 2014 (Figure 5.5). The other two fields that recorded an increase in the share of GERD were Medical and Health Science,

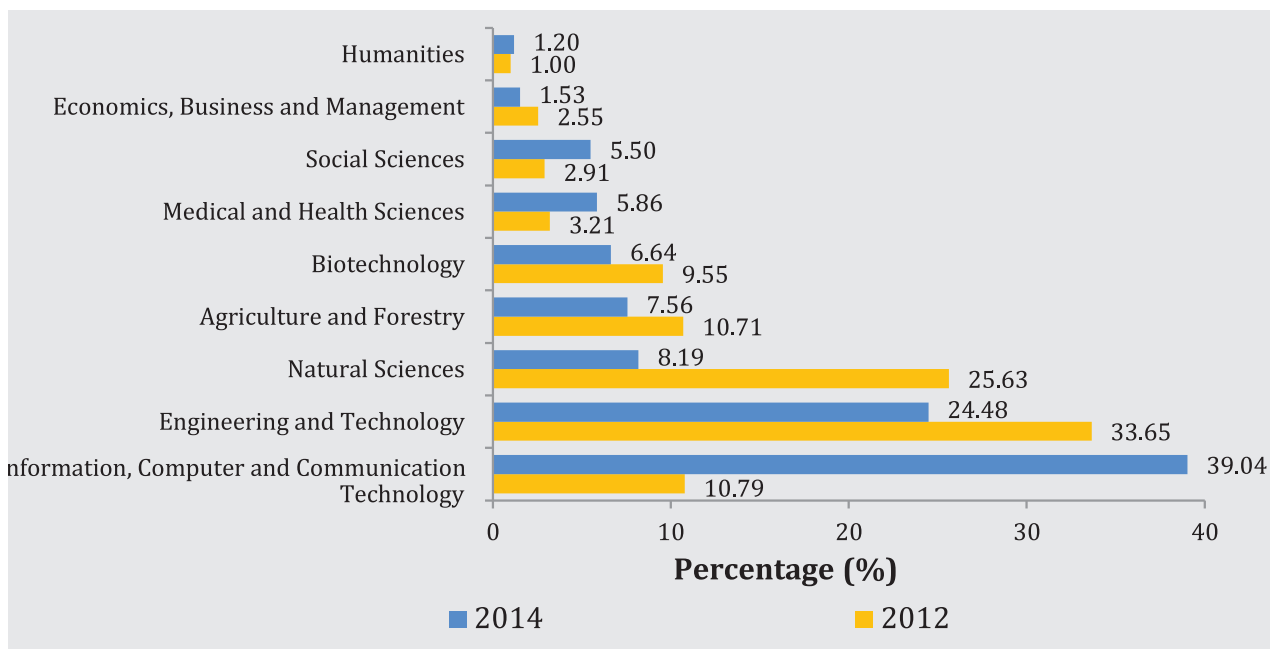
and Social Sciences increasing from 3.21% to 5.86% and 2.91% to 5.50% respectively. Meanwhile, other fields recorded a decrease in the share of GERD. The share of Engineering and Technology recorded a drop from 33.65% to 24.48%, and Natural Sciences from 25.63% to 8.19% for the same period. Agriculture and Forestry (from 10.71% to 7.56%), and Biotechnology (from 9.55% to 6.64%) also recorded significant decreases.

Figure 5.4 GERD Distribution by Field of Research, 2014



Source : National Survey of R&D in Malaysia 2015

Figure 5.5 GERD by Field of Research Comparison, 2012 and 2014

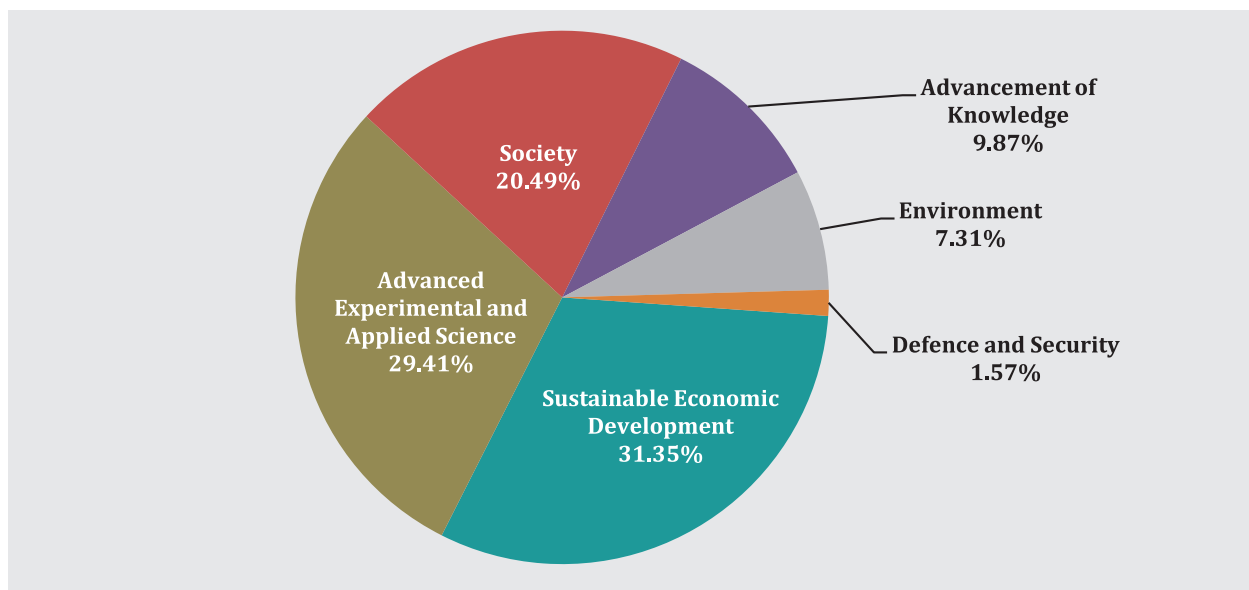


Source : National Survey of R&D in Malaysia 2015

5.4.2 R&D Expenditure by SEO

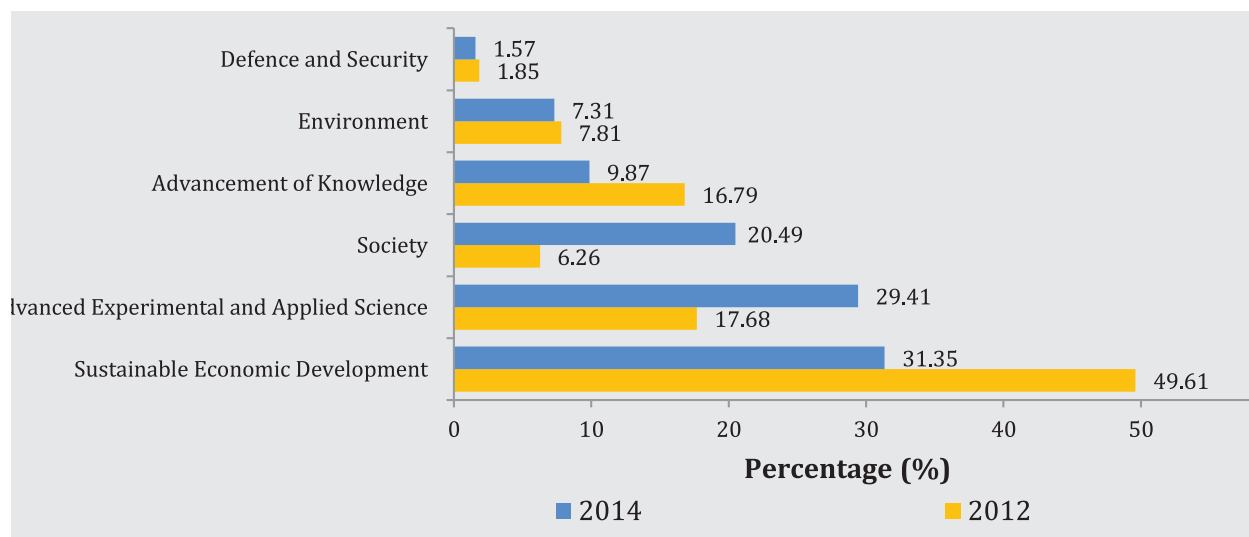
For Socio-Economic Objectives (SEOs) of R&D, Sustainable Economic Development (31.35%), Advanced Experimental and Applied Science (29.41%), and Society (20.49%) were the top three objectives of R&D activities across all SEOs in Malaysia in 2014 (Figure 5.6). This is followed by Advancement of Knowledge (9.87%), Environment (7.31%), and Defence and Security (1.57%) respectively. Comparing the R&D activities trend in Malaysia between 2012 and 2014 indicates Sustainable Economic Development as the top SEO in both years (Figure 5.7). Moreover, Sustainable Economic Development recorded half of the GERD share in 2012. This was not surprising given that sustainable development has been recognised as one of the main national and international research agendas. Meanwhile, Advanced Experimental and Applied Science marked a huge increase from 17.68% in 2012 to 29.41%, becoming the second major SEO in 2014. R&D related to Society has shown a remarkable increase, from 6.26% in 2012 to 20.49% in 2014. However, a sharp decline is observed in the share of Advancement of Knowledge, falling from 16.79% in 2012 to 9.87% in 2014. Environment and Defence and Security declined slightly from 7.81% to 7.31% and 1.85% to 1.57% respectively.

Figure 5.6 GERD Distribution by Socio-Economic Objective, 2014



Source : National Survey of R&D in Malaysia 2015

Figure 5.7 GERD Distribution by Socio-Economic Objective Comparison, 2012 and 2014

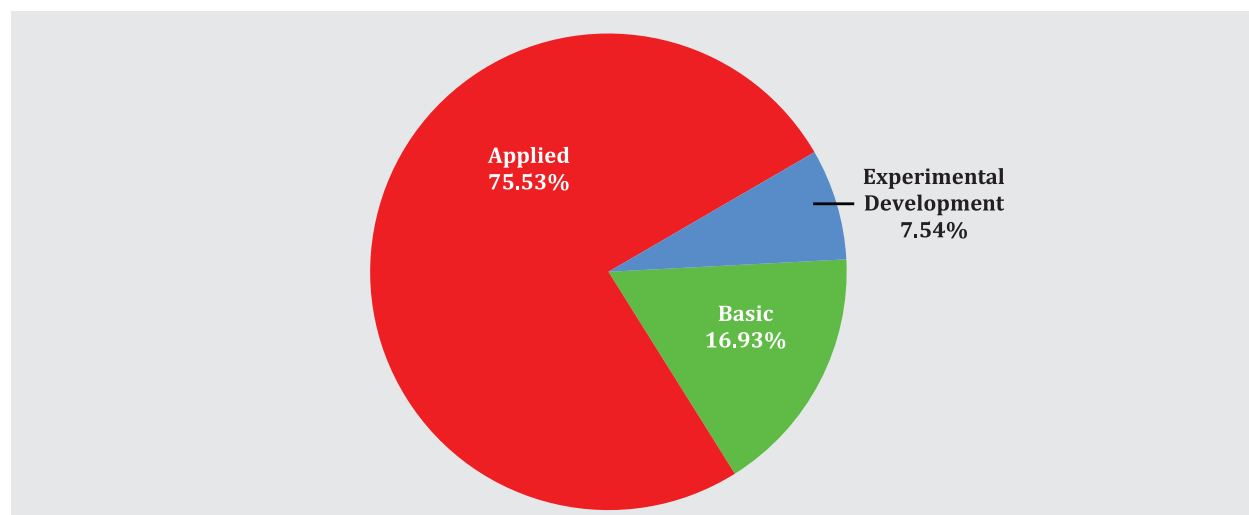


Source : National Survey of R&D in Malaysia 2015

5.5 R&D Expenditure by Research Type

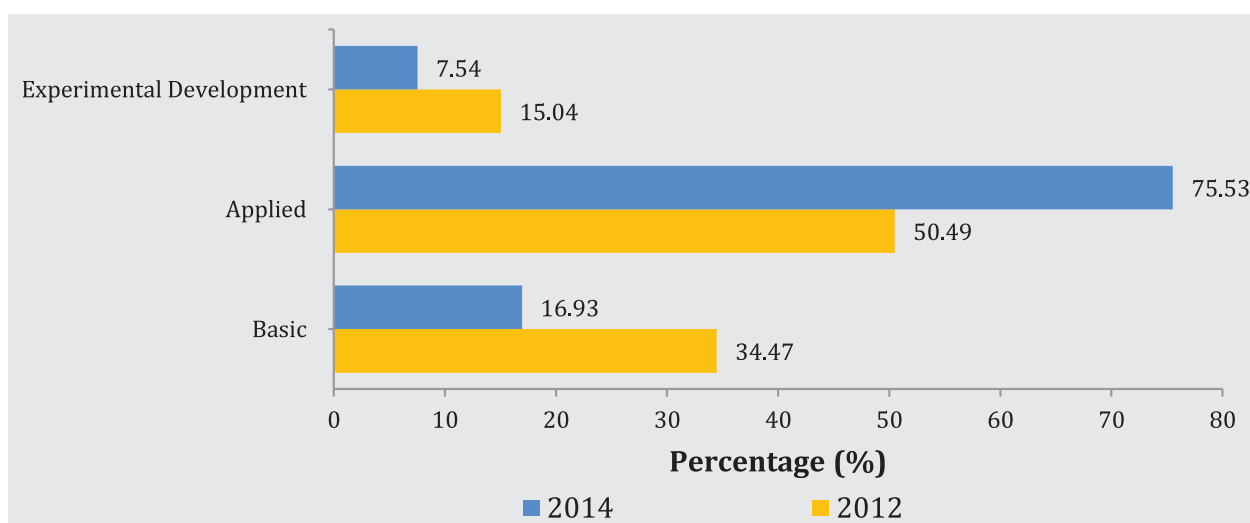
Across all types of research activities, Applied Research recorded three quarters of the overall R&D expenditure in Malaysia in 2014, accounting for 75.53% or RM10.55 billion. Basic Research and Experimental Development Research accounted for 16.93% or RM2.4 billion and 7.54% or RM1.05 billion respectively (Figure 5.8). For both the years 2012 and 2014, Applied Research dominated the R&D activities in Malaysia (Figure 5.9). In fact, its contribution increased from 50.49% in 2012 to 75.53% in 2014. This notable rise reflects the various government agendas and initiatives in promoting applied research with higher commercialisation potential. Basic Research share declined from 34.47% in 2012 to 16.93% in 2014, while Experimental Development dropped to 7.54% in 2014 from 15.04% in 2012. Besides these, Applied Research dominates all sectors (Figure 5.10).

Figure 5.8 GERD Distribution by Type of Research, 2014



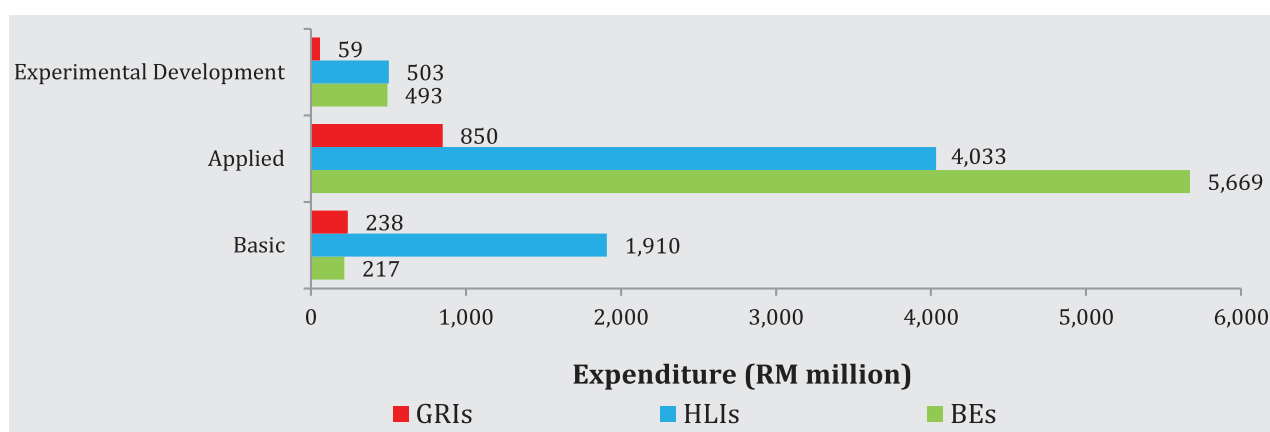
Source : National Survey of R&D in Malaysia 2015

Figure 5.9 GERD Distribution by Type of Research Comparison, 2012 and 2014



Source : National Survey of R&D in Malaysia 2015

Figure 5.10 Type of Research by Sector, 2014

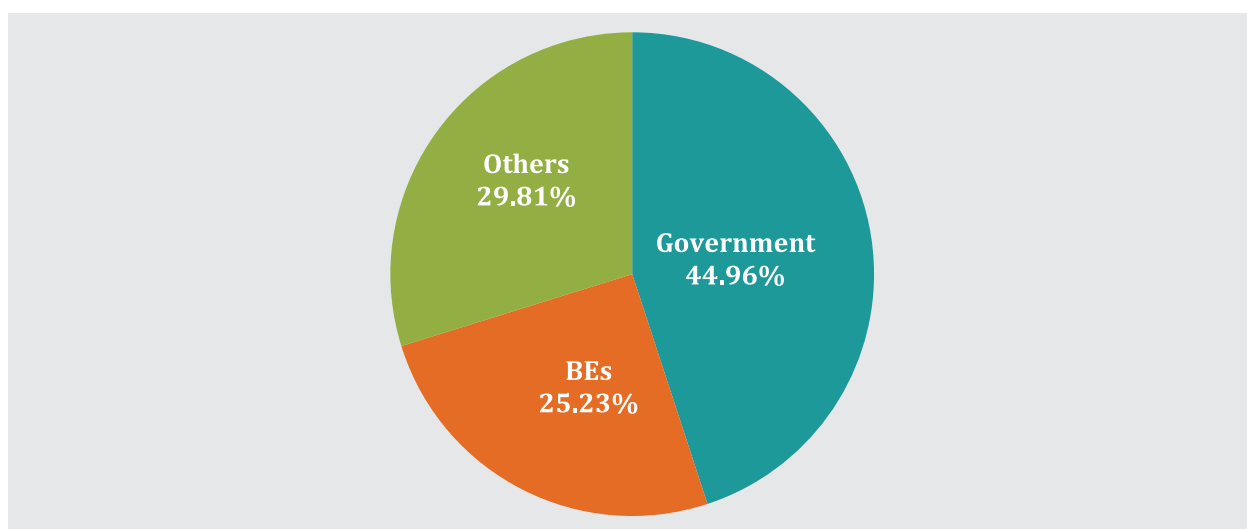


Source : National Survey of R&D in Malaysia 2015

5.6 Sources of R&D Funds

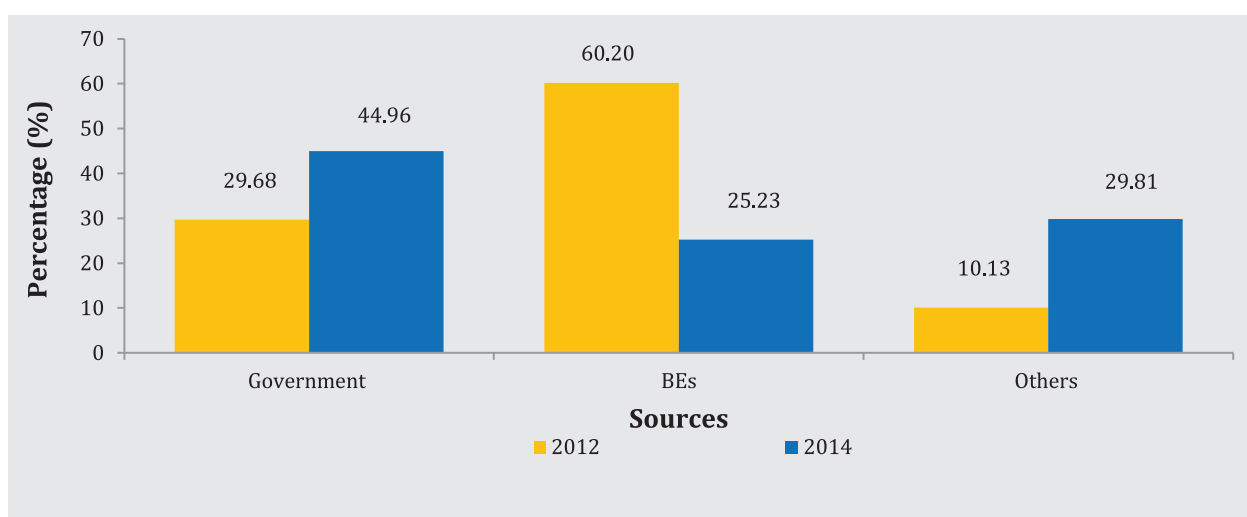
In general, R&D funds are secured from three main sources, namely: Government, including federal government R&D funds, state or local government funds, and specific ministries; BEs, including public funds from corporations and quasi-corporations owned by government units such as GLCs, and private money from corporations and quasi-corporations; and Others, including other private sectors and NGO funds. In 2014, R&D activities in Malaysia were mainly public driven, with nearly 44.96% of R&D funds secured from the Government (Figure 5.11). BEs funded 25.23% of the R&D activities in Malaysia, while the remaining 29.81% came from Others. Government funding recorded a significant increase between 2012 and 2014, increasing from 29.68% to 44.96%. Funding from Others tripled during the same period. However, BEs funding declined more than half, from 60.20% in 2012 to 25.23% in 2014 (Figure 5.12).

Figure 5.11 Source of R&D Funds, 2014



Source : National Survey of R&D in Malaysia 2015

Figure 5.12 Source of R&D Funds, 2012 and 2014



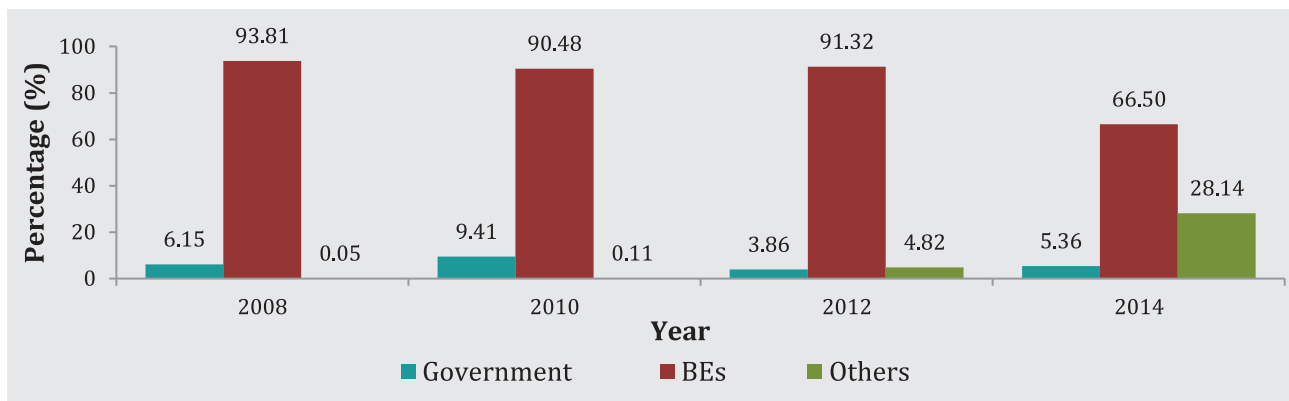
Source : National Survey of R&D in Malaysia 2015

Some of the major observations can be summarised as follows:

- Source of R&D funds in BEs – In the past, BEs had been the main source of R&D funding, accounting for more than 90% of total funding especially during the period of 2008 – 2012 (Figure 5.13). Nevertheless, the share of BE funds decreased to 66.5% in 2014. By contrast, funding from Others – especially foreign funds – increased remarkably to 28.14% in 2014, which was the highest share recorded since 2008. On the other hand, over the last six years funding from the Government has been minimal, fluctuating in the range of 3.86% to 9.41%.

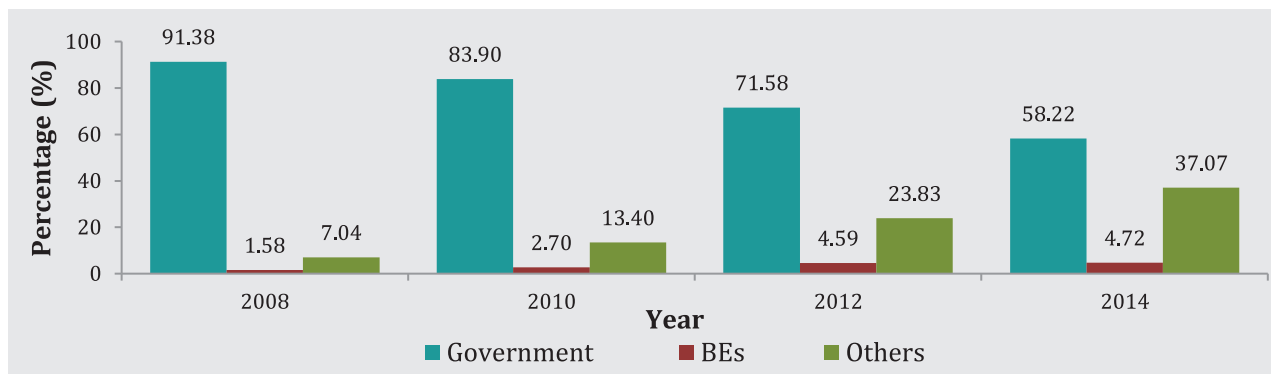
- Source of R&D funds in HLIs – Although the Government is always the main source of R&D funding for HLIs, the dominance of Government funding has gradually declined over the six year period between 2008 – 2014, from 91.38% in 2008 to 58.22% in 2014 (Figure 5.14). This reflects the Government's initiative to have HLIs be more self-sufficient and to reduce the over-dependency on public funding. The Government has encouraged HLIs to be more self-sufficient in R&D funding, and as a result sources of funding from BEs increased from only 1.58% in 2008 to 4.72% in 2014. HLIs have also been receiving significant funding from Others such as foreign funds and an institution's own funds, recording an increase from 7.04% in 2008 to 37.07% in 2014.
- Source of R&D funds in GRIs – The Government has always been the main source of R&D funds for GRIs over the period of 2008 – 2014 (Figure 5.15). Nevertheless, there was a significant decline in Government funding of GRIs after 2010. In 2014, funds secured from the Government was 60.40%, which was the lowest share over the last four years. Funding from Others such as institution's own funds, foreign funds and other funds increased dramatically to 39.10% in 2014. Many of the GRIs were funded by their institution's own funding, which is generated through training and services. On the other hand, funds from BEs were insignificant for GRIs.

Figure 5.13 Sources of R&D Funds in BEs, 2008 – 2014

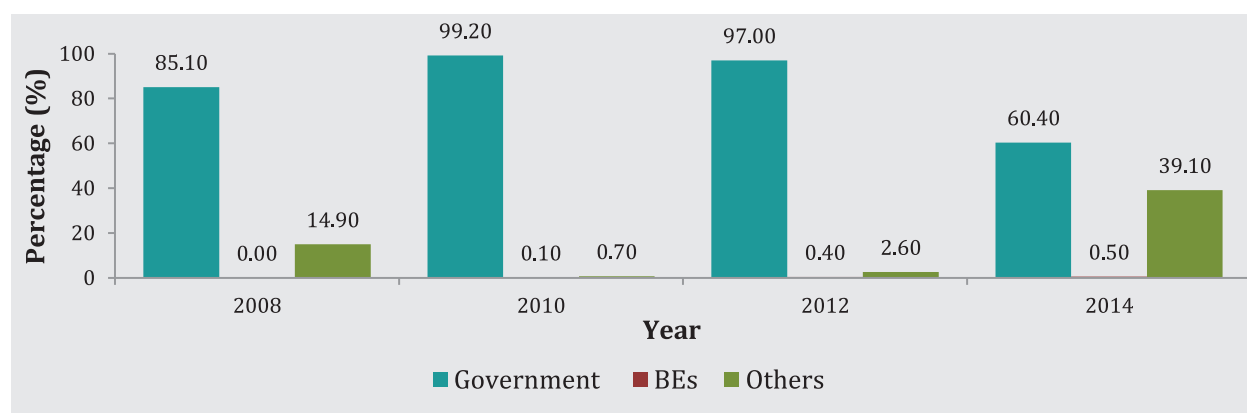


Source : National Survey of R&D in Malaysia 2015

Figure 5.14 Sources of R&D Funds in HLIs, 2008 – 2014



Source : National Survey of R&D in Malaysia 2015

Figure 5.15 Sources of R&D Funds in GRIs, 2008 – 2014

Source : National Survey of R&D in Malaysia 2015

5.7 R&D Personnel

5.7.1 Researcher Headcount by Qualification

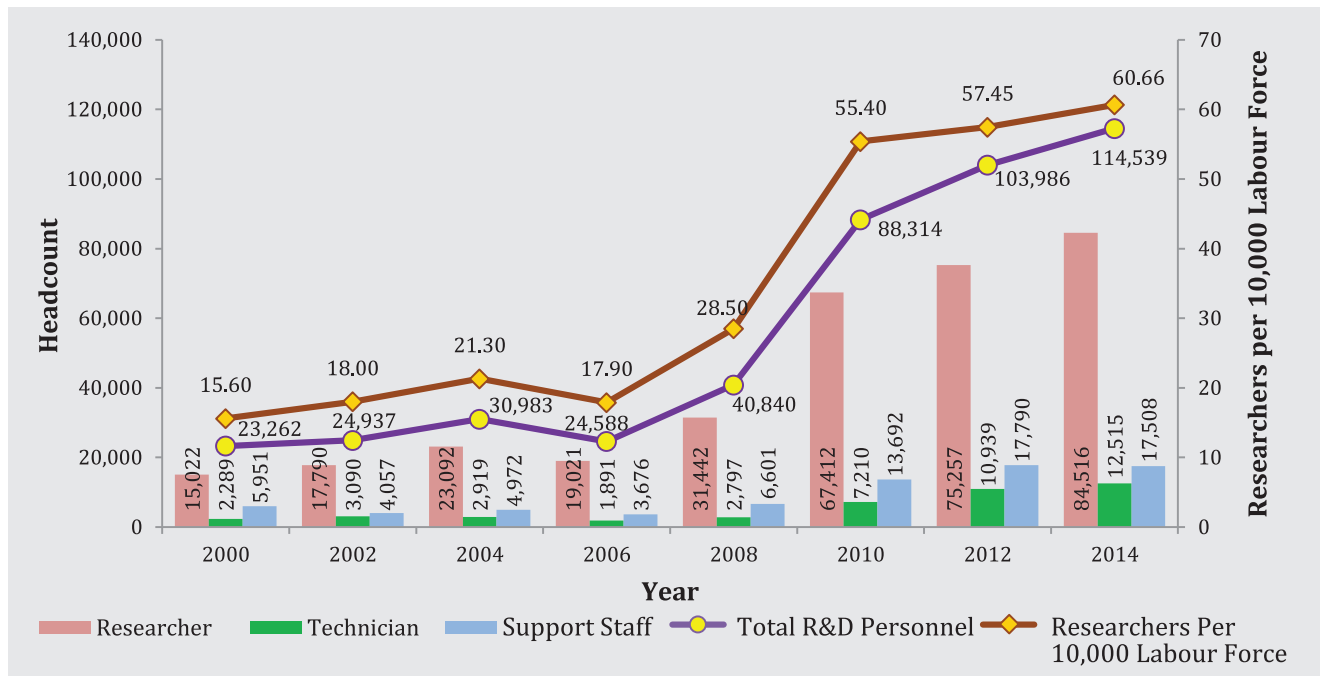
R&D performance depends on the R&D personnel¹⁶, as the competencies and knowledge required for R&D activities are heavily embodied in researchers. Except for 2006, Malaysia's number of R&D personnel and researchers per 10,000 labour force recorded an upward trend since 2000 (Figure 5.16). After a decline in 2006, Malaysia's R&D labour force rebounded strongly and experienced an impressive growth for the subsequent years. In 2014, the total R&D personnel stood at 114,539 persons, whereas the ratio of researchers to 10,000 workforce was 60.66. The total R&D personnel in Malaysia was made up of 84,516 Researchers, 17,508 Support Staff and 12,515 Technicians. The number of researchers has significantly increased since 2008.

In 2004, researchers with Master's degrees made up 63.81% of the overall research community in the country (Figure 5.17). This is followed by researchers with PhD degrees (20.90%), Bachelor's degrees (13.27%) and Non-Degree/Diploma (2.03%). The headcount¹⁷ of researchers by qualification is shown in Figure 5.18. There was a major shift in both the proportion and headcount of researchers with Master's and PhD degrees during 2012 – 2014 due to the reclassification of researchers with Master's and PhD degrees in the National Survey of R&D 2015.

¹⁶ R&D personnel encompasses all persons directly employed in R&D (mainly researchers, technicians and other support staff) and those providing direct services to the conduct of R&D (such as R&D managers, administrators and clerical staff). These people may be fully or partially engaged in R&D activities. Individuals providing indirect services, such as canteen and security staff, were excluded.

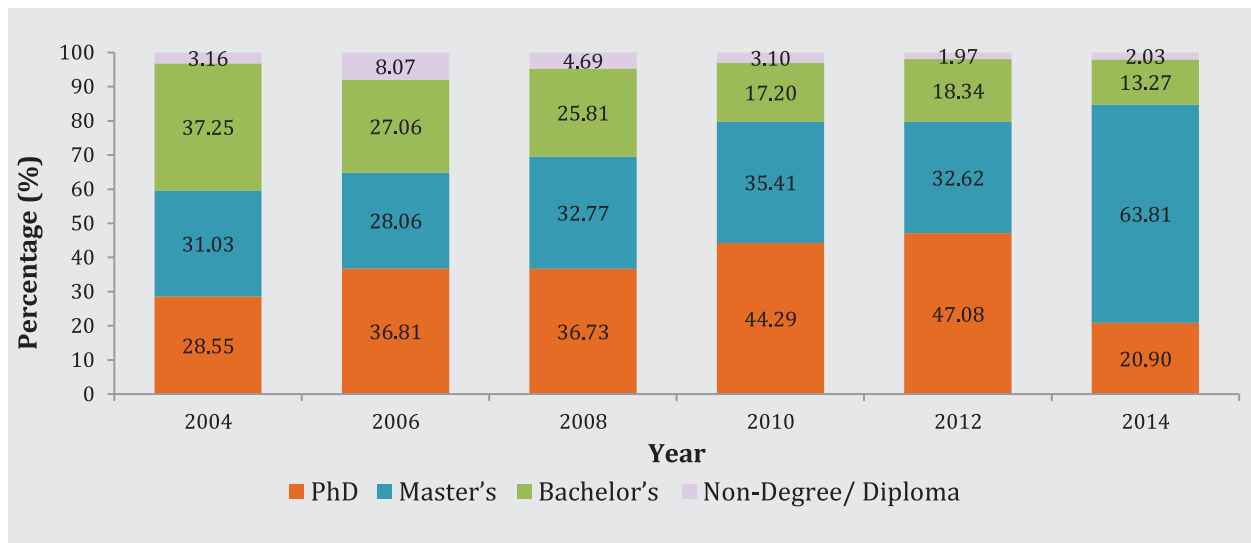
¹⁷ Headcount refers to the total number of individuals who are mainly or partially employed in R&D. This includes both "full-time" and "part-time" employed staff.

Figure 5.16 R&D Personnel and Researchers per 10,000 Labour Force 2000 - 2014

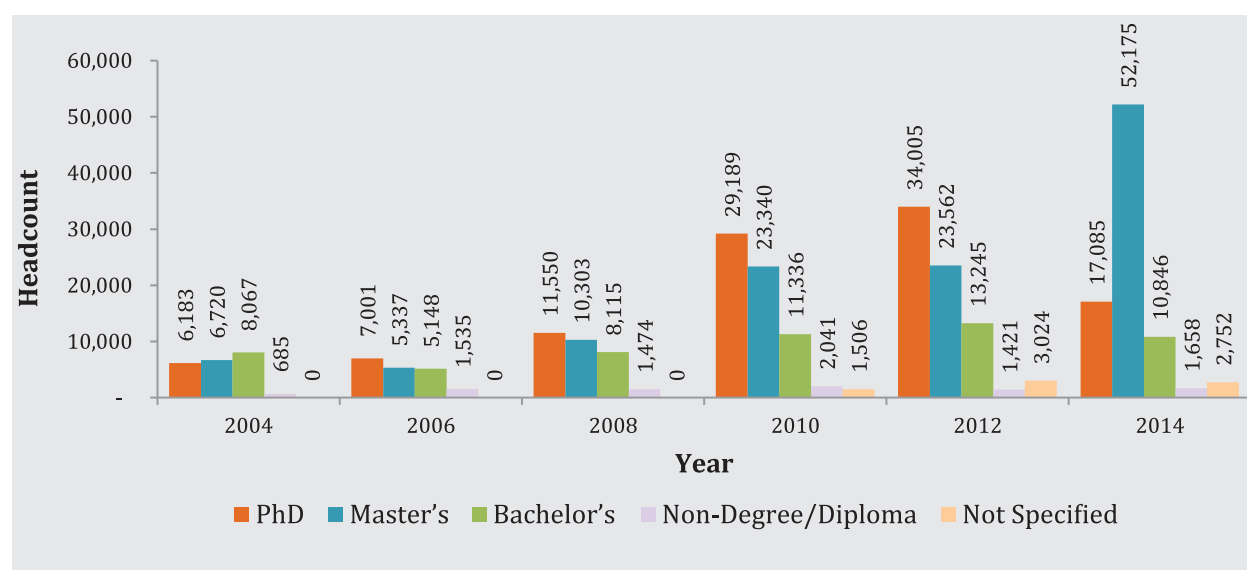


Source : National Survey of R&D in Malaysia 2013, 2015

Figure 5.17 Proportion of Researchers by Qualification, 2004 - 2014



Source : National Survey of R&D in Malaysia 2006, 2013, 2015

Figure 5.18 Headcount of Researchers by Qualification, 2004 – 2014

Source : National Survey of R&D in Malaysia 2013, 2015

5.7.2 Full-time Equivalent

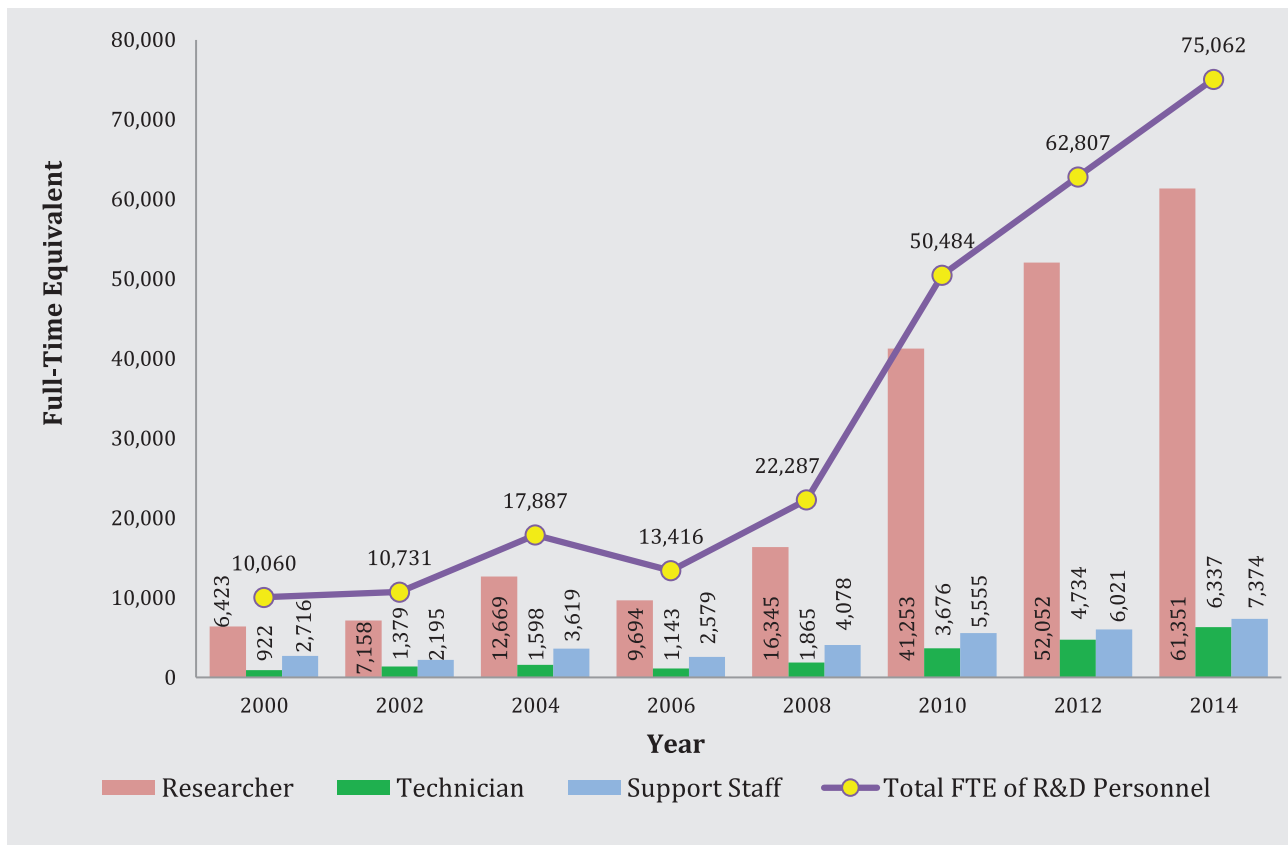
Full-Time Equivalent (FTE¹⁸) of R&D personnel indicates the amount of time that a researcher devotes to R&D projects during a specific reference period (usually one calendar year). It reflects the researcher's R&D intensity in terms of time spent. FTE of R&D personnel in Malaysia showed a positive trend since 2000, except for 2006 (Figure 5.19). An impressive trend is observed during 2008 – 2014 in which the FTE tripled from 22,287 to 75,062. FTE of Researchers nearly quadrupled from 16,345 in 2008 to 61,351 in 2014. Technicians grew more than triple from 1,865 to 6,337 while Support Staff almost doubled from 4,078 to 7,374.

5.7.3 Researcher Headcount by Gender

An analysis of researchers by gender shows that the number of female researchers participating in R&D activities has increased significantly in the period of 2008 – 2010, followed by a gradual increase from 2010 – 2014. The highest number of female researchers recorded was 41,226 in 2014 (Figure 5.20). However, the proportion of female researchers to the total number of researchers declined slightly, from 49.92% in 2012 to 48.78% in 2014. This is due to the slower growth in female researchers compared to male researchers. Between 2012 and 2014 growth in female researchers was 9.74%, while male researchers grew at the rate of 14.9%.

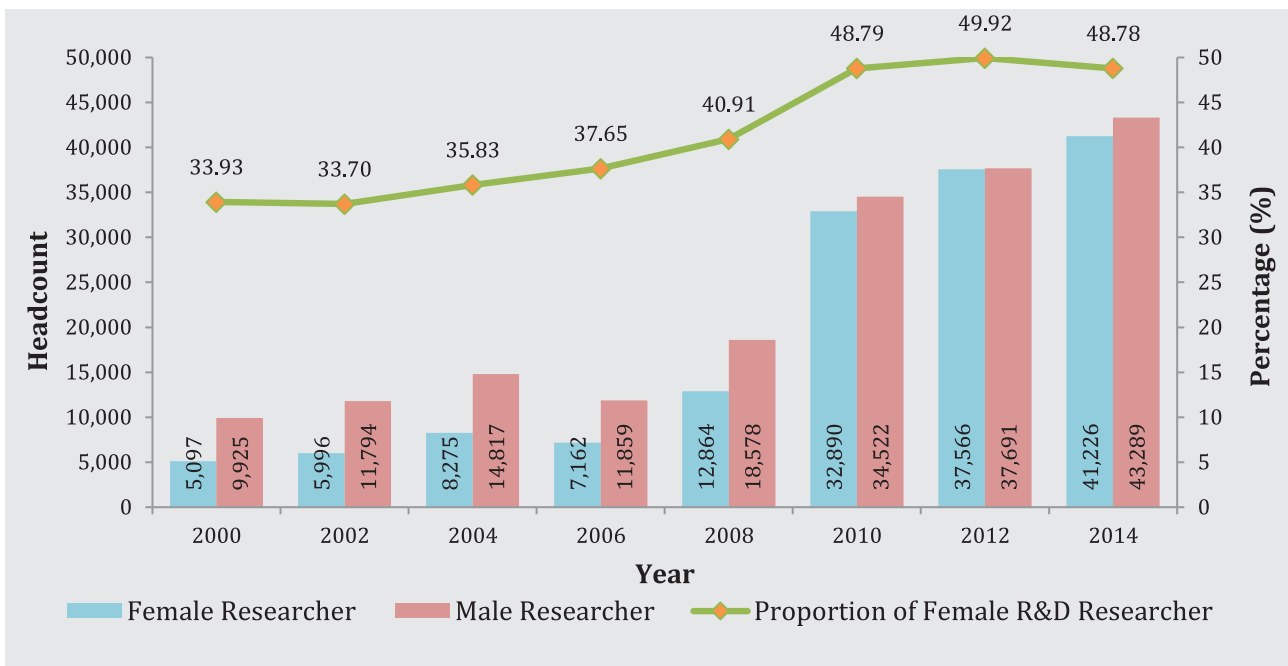
¹⁸ FTE is the measurement unit of R&D personnel. One FTE may be considered as one person-year. Thus, a person who normally spends 30% of his/her time on R&D and the rest of the time on other activities (such as teaching, university administration and student counseling) was considered as 0.3 FTE.

Figure 5.19 Full-Time Equivalent of R&D Personnel, 2000 – 2014



Source : National Survey of R&D 2013, 2015

Figure 5.20 Headcount of Researchers by Gender, 2000 – 2014



Source : National Survey of R&D 2013, 2015

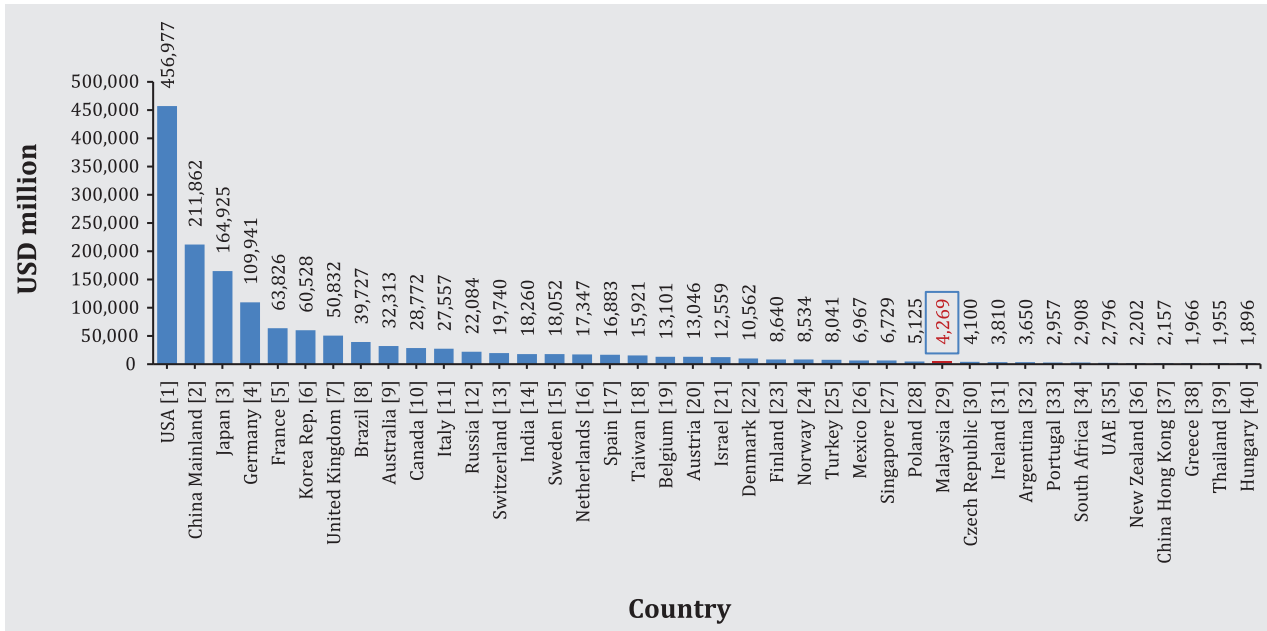
5.8 International Comparisons

This section compares Malaysia's R&D performance with selected countries, including Organisation for Economic Co-operation and Development (OECD) countries, East Asia's Newly Industrialised Economies (NIEs), and members of the Association of Southeast Asian Nations (ASEAN). For data consistency, international data sets on countries' total expenditure on R&D and R&D personnel were obtained from a single source, i.e. the IMD World Competitiveness Yearbook (WCY). However, country data on the proportion of female researchers was retrieved from the United Nations Educational, Scientific and Cultural Organisation (UNESCO) Institute for Statistics as the data is not available in WCY. The comparisons were made by benchmarking Malaysia's performance within a group of 40 top performing countries in each R&D and human capital criterion for 2014 (or the latest year).

Listed below is the summary of the comparison study on global trends on R&D intensity and R&D personnel:

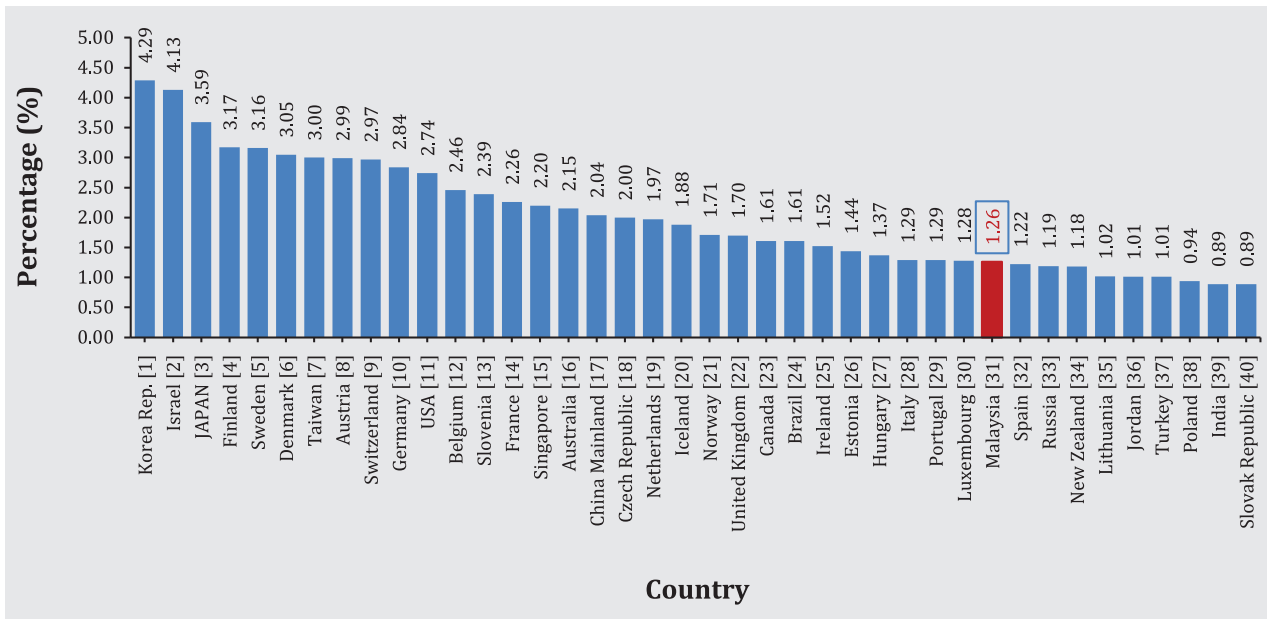
- Total expenditure on R&D – R&D expenditures by region and economies provides an overview of the R&D commitments and capabilities. The total R&D expenditure by 40 top performing economies amounted to USD1.50 billion in 2014. The USA remained the world's largest R&D investor, with USD456.98 billion or 30.39% of the total GERD of these 40 economies (Figure 5.21). China was ranked second with USD211.86 billion, followed by Japan at USD164.93 billion. It is important to note that the top 5 performing countries namely the USA, China Mainland, Japan, Germany and France contributed to 67.01% of the total GERD of these 40 economies. Malaysia was ranked 29th with a total R&D spending of USD4.27 billion. Among the East Asian NIEs, Malaysia was ranked behind China and India. In ASEAN, Malaysia was ranked behind only Singapore (USD5.79 billion).
- R&D intensity – GERD as a percentage of GDP is a suitable indicator to compare the R&D activities, since it takes into account the size of the country. In 2014, Malaysia's GERD per GDP was ranked 31st, comprising 1.26% from among the 40 top performing countries (Figure 5.22). This has brought Malaysia level with some OECD countries such as Luxembourg (1.28%) and Spain (1.22%). The top three countries that led the league were the Republic of Korea (4.29%), Israel (4.13%), and Japan (3.59%). Among the East Asian NIEs, Malaysia was ranked behind China Mainland (2.04%) but ahead of India (0.89%). In ASEAN, Malaysia was leading the other countries except Singapore (2.20%).
- Business R&D intensity – BERD per GDP is an important measure of business commitment to R&D and innovation. Indeed, BERD supports an enterprise's technological progress and sustains the nation's long-term productivity growth. For BERD/GDP ratio, Malaysia was ranked 33rd at 0.58% which was second after Singapore (1.34%) in the ASEAN region (Figure 5.23). Israel (3.49%), the Republic of Korea (3.35%) and Japan (2.79%) were the top performers. These were followed by other OECD countries such as Finland (2.15%), Sweden (2.12%), Austria (2.11%), Switzerland (2.05%), Denmark (1.95%), and the USA (1.94%).
- Total R&D personnel per capita – In terms of FTE per 1,000 people, Denmark (10.44), Taiwan (10.26) and Israel (9.69) were leading the 40 top performing economies (Figure 5.24). Malaysia was at 40th place with 2.45. In fact, China (2.71) and Malaysia were the only two East Asian NIEs listed among the 40 top performing countries. Among the ASEAN nations, Malaysia was far behind Singapore (7.78).
- Female researchers – Malaysia ranked 16th with 48.78% in the percentage of female researchers over the total number of researchers (Figure 5.25). Among ASEAN nations, Malaysia was ranked third after Thailand (53.28%) and the Philippines (49.46%).

Figure 5.21 Total Expenditure on R&D by Country, 2014



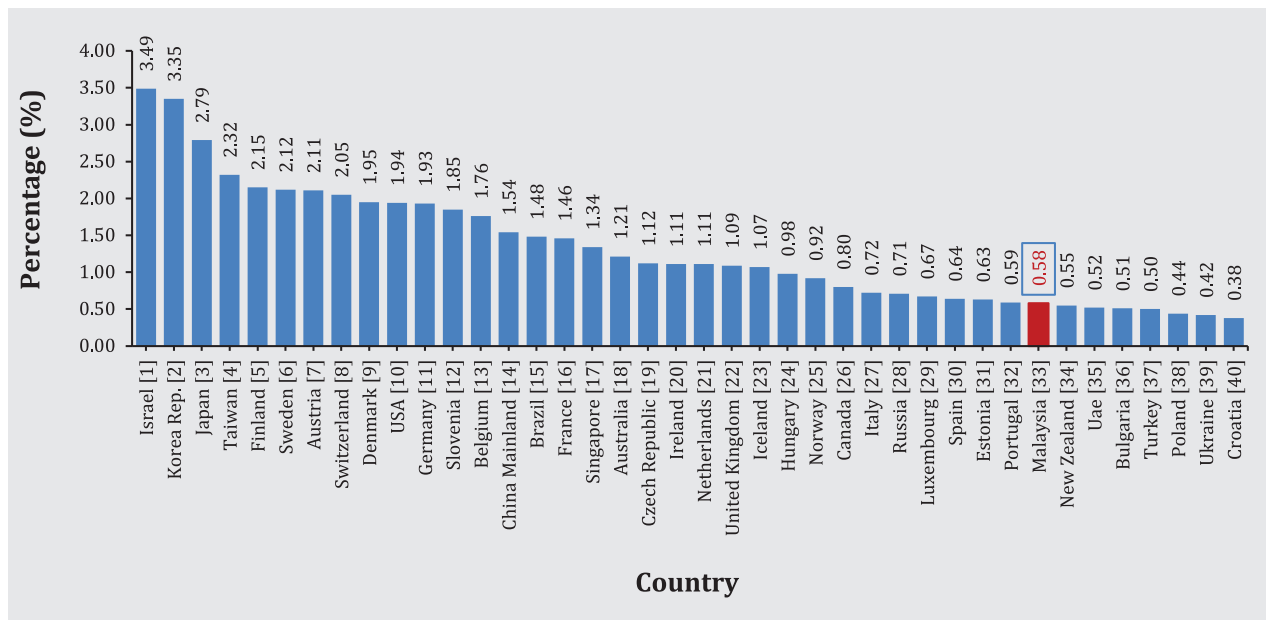
Note : South Africa (year 2012); Argentina, Australia, Brazil, New Zealand & USA (year 2013)
 Source : IMD World Competitiveness Yearbook 2016

Figure 5.22 GERD per GDP by Country, 2014



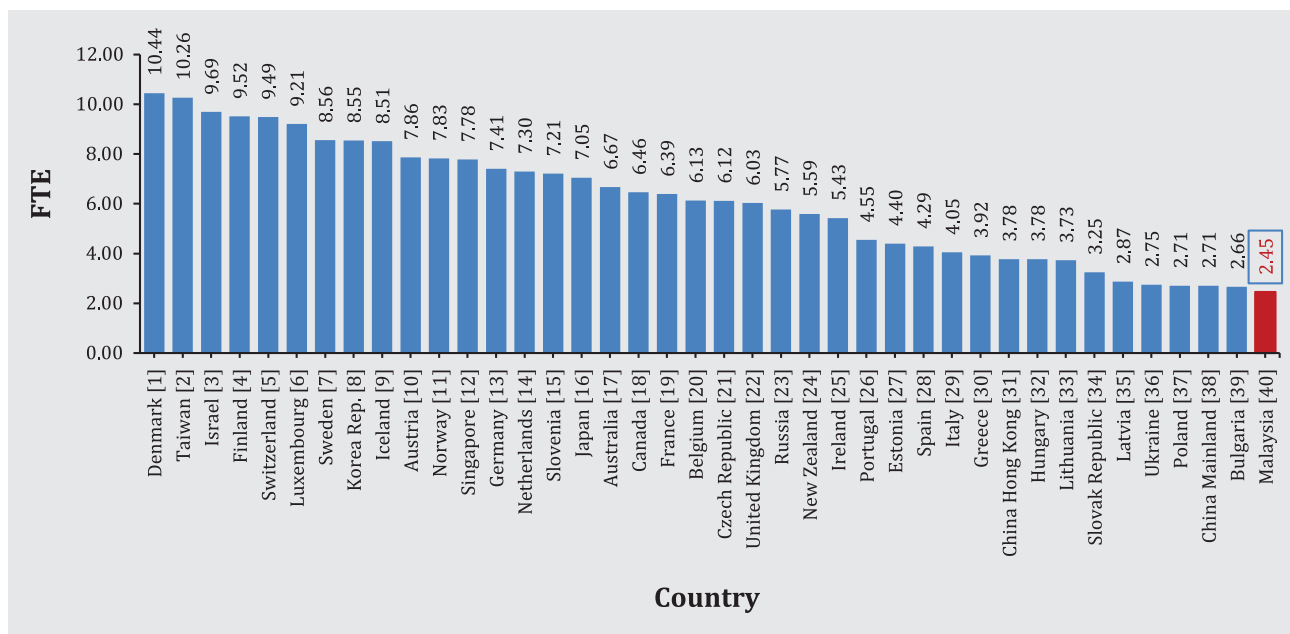
Note : Jordan (year 2010); Switzerland (year 2012); Australia, Brazil, New Zealand & USA (year 2013)
 Source : IMD World Competitiveness Yearbook 2016

Figure 5.23 BERD per GDP by Country, 2014

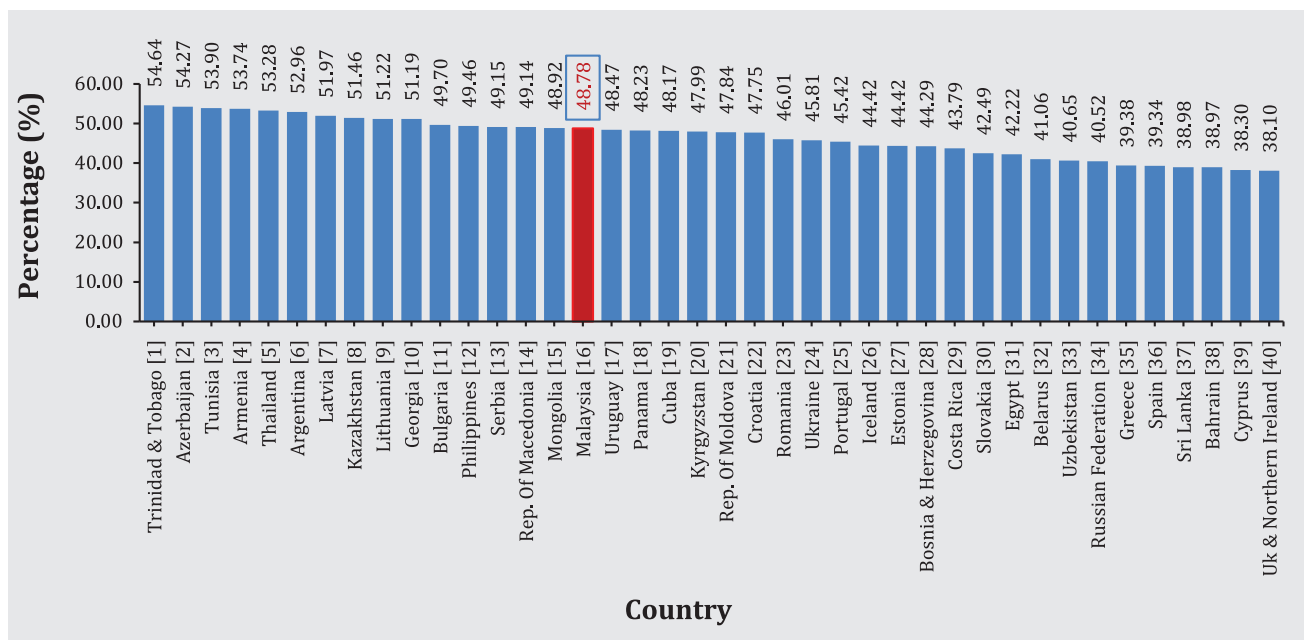


Note : Brazil (year 2011); Switzerland (year 2012); Australia, Ukraine, USA & New Zealand (year 2013)
 Source : IMD World Competitiveness Yearbook 2016

Figure 5.24 FTE per 1,000 People by Country, 2014



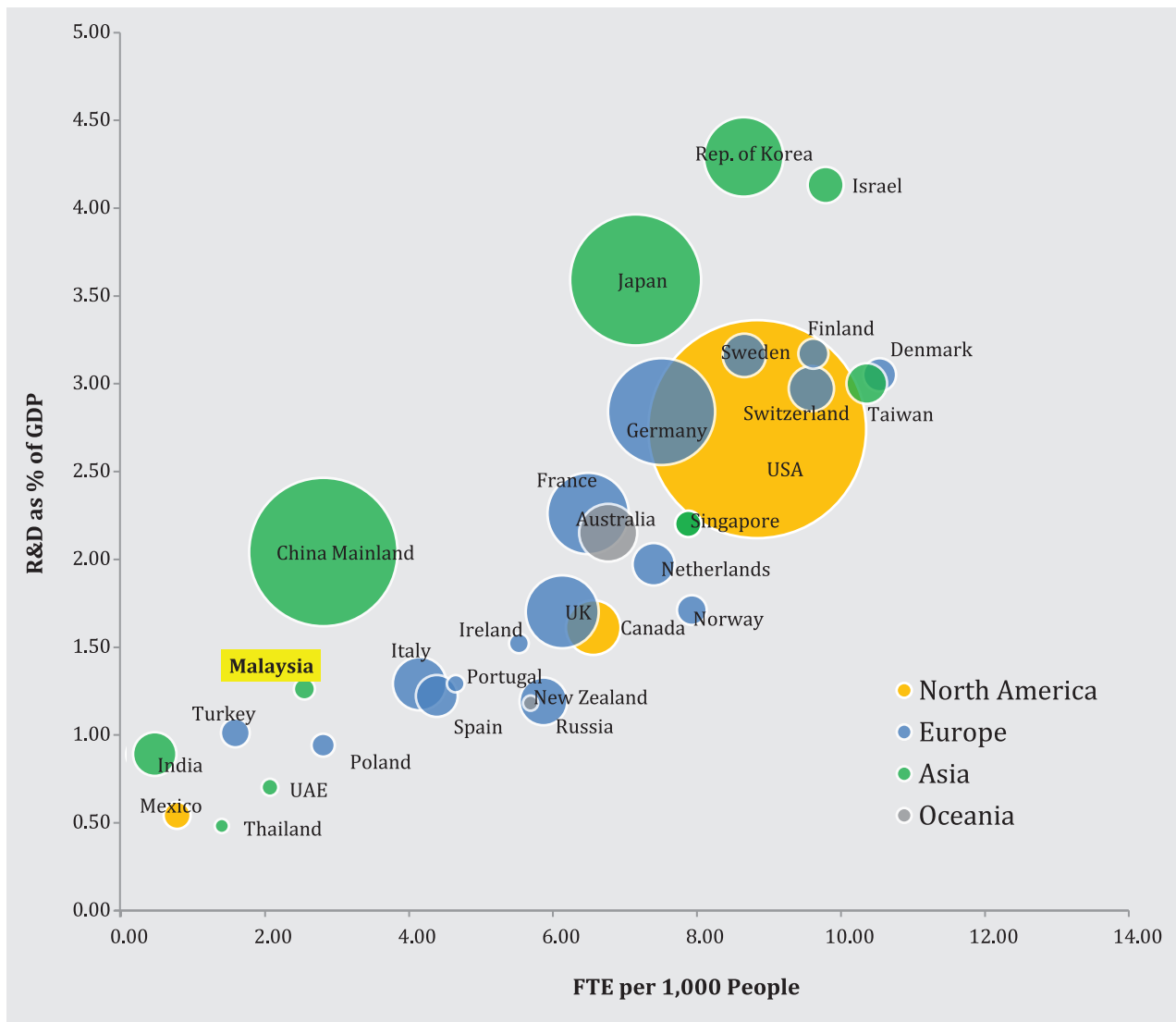
Note : Australia (year 2010); Israel & Switzerland (year 2012); Canada, Iceland, Lithuania & New Zealand (year 2013)
 Source : IMD World Competitiveness Yearbook 2016

Figure 5.25 Proportion of Female Researchers by Country, 2014

Note : Belarus, Bulgaria, Croatia, Cyprus, Estonia, Greece, Latvia, Lithuania, Panama, Philippines, Spain & Sri Lanka (year 2013)
 Source : UNESCO Institute for Statistics

In general, the 2014 global trend shows that the R&D investment intensity (i.e. R&D as percentage of GDP) of a nation correlates with the R&D personnel intensity (i.e. FTE per 1,000 people) (Figure 5.26). This implies investment in R&D activities goes hand-in-hand with the growth in the number of researchers in STI. R&D in the USA was driven by strong R&D investment and researcher intensities, coupled with huge spending in R&D activities which is reflected by the size of the bubble in the figure. Japan and China Mainland were similar in the amount of annual R&D spending. However, Japan exhibited a better performance in terms of R&D intensity and researcher intensity. It is noteworthy that China, Japan, some other Asian countries (e.g. Republic of Korea and Taiwan) and several European countries (e.g. Denmark, Finland, Sweden and Switzerland) are able to sustain their global competitiveness based on the high R&D and researcher intensities – despite a smaller total R&D spending compared to the USA. Malaysia was still considered lagging behind in the overall R&D investment. Nevertheless, Malaysia's R&D investment and researcher intensity are strongly correlated, and this indicates that the country has balanced its human capital development and R&D spending equally.

Figure 5.26 Global Trends in R&D Investment and Research Workforce, 2014



Note : Chart generated based on IMD World Competiveness Yearbook 2016 data for year 2014 (or the latest year). FTE data for USA is retrieved from OECD (R&D Statistics). Size of circle reflects the relative amount of annual R&D spending by the indicated country.

Source : Unit Perundingan Universiti Malaya

5.9 Summary

In 2014, Malaysia’s GERD and the percentage of GERD over GDP stood at RM13.97 billion and 1.26%, respectively. HLIs contribution to GERD doubled from RM3.04 billion to RM6.44 billion in 2014, surpassing BEs for the first time over the period of 2000 – 2014. Information, Computer and Communication Technology, Engineering and Technology, and Natural Sciences were the top three fields that contributed the most to GERD, while Sustainable Economic Development was ranked the top SEO in R&D activities in Malaysia for both the years 2012 and 2014. Meanwhile, Applied Research recorded three quarters of the overall R&D expenditure in Malaysia in 2014, and R&D activities in Malaysia were generally public driven.

In 2014, the total R&D personnel for Malaysia stood at 114,539 persons while the ratio of researchers to 10,000 workforce was 60.66, both new milestones for the nation. The FTE tripled in the period of 2008 – 2014, from 22,287 to 75,062. On the other hand, the proportion of female researchers to the total number of researchers slightly declined from 49.92% in 2012 to 48.78% in 2014.

In the global R&D arena, the comparison of Malaysia's performance within the group of 40 best performing economies in the world in year 2014 indicated that Malaysia ranked 29th in total R&D expenditure, 31st in GERD as percentage of GDP and 33rd in BERD. In terms of R&D personnel, Malaysia ranked 40th in FTE per 1,000 people. Malaysia ranked 16th for the



Public Sector R&D Investment - Major Grants and Programmes

01 Pre-R&D Stage

02 Research Stage

03 Development Stage

04 Commercialisation Stage

05 MIDA's R&D Investment
Initiatives

▶▶ CHAPTER 6

Approved Projects (2011 – 2015)

Cradle Funds

134 CIP Catalyst projects

RM44.88 m

7 U-CIP Catalyst projects

RM1.05 m

147 CIP 500 projects

RM72.19 m

ScienceFund

1,489 projects

RM309.27 m

FRGS

6,874 projects

RM631.80 m

TechnoFund

113 projects

RM212.05 m

InnoFund

83 projects

RM23.21 m

MAC3 Fund

78 projects

RM83.23 m

BCi2 Fund

36 projects

RM27.21 m

CRDF

100 projects

RM174.05 m

TAF

6 projects

RM11.45 m

BCF

25 projects

RM71.7 m

PCF

32 projects

RM20.93 m

57 R&D projects



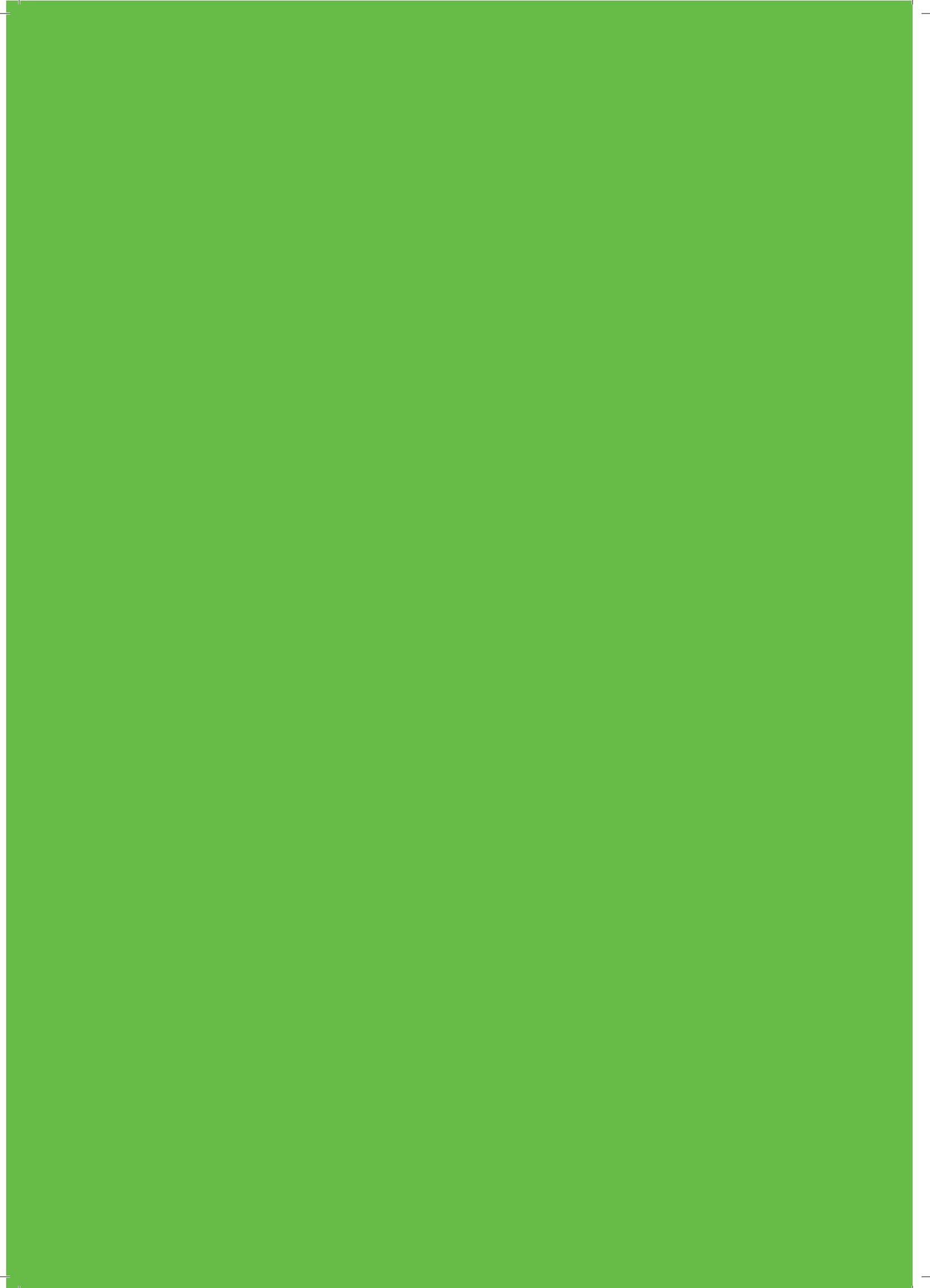
■ 28 Contract R&D Company

■ 14 R&D Status Company

■ 10 Pre-Packaged R&D

■ 4 R&D In-House

■ 1 R&D Company



CHAPTER 6: PUBLIC SECTOR R&D INVESTMENT – MAJOR GRANTS AND PROGRAMMES

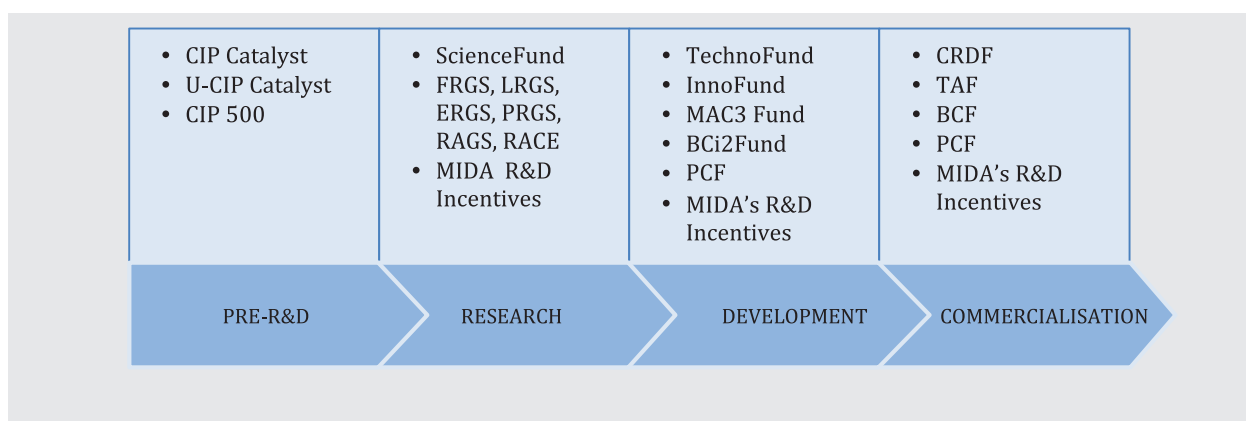
6.1 Introduction

Public R&D funding and programmes indicate the commitment of the Government to strengthening the country's overall scientific and innovation performance. Indeed, public sector funding is crucial as it focuses on basic and applied research, as well as fosters national research agendas that aim to improve societal well-being. Also, public sector R&D investment – especially for R&D in HLIs – is an essential platform for the country to produce quality researchers who will lead future R&D activities. For private companies, the supply of public R&D funds and incentives is effective in inducing companies to invest in R&D activities. While private investment in R&D is largely associated with a firm's expected return on investment, public R&D funding and programmes are oriented towards generating high social returns through R&D activities. This chapter provides insights into the various supports of the public sector that includes R&D grants, programmes and incentives.

6.2 Public R&D Funding Ecosystem

A wide range of public R&D grants, incentives and programmes have been designed and implemented by the various ministries and agencies in Malaysia to support R&D activities at different stages. Generally, the funding spectrum encompasses four stages of R&D activities that range from: (a) pre-R&D or the stage of ideation; (b) research stage; (c) development stage; and (d) commercialisation stage (Figure 6.1).

Figure 6.1 R&D Funding Spectrum in Malaysia



Source : Ministry of Science, Technology and Innovation Malaysia

6.3 Public R&D Grants

The status and performance of various public R&D grants are presented according to the stages of funding of the national R&D ecosystem.

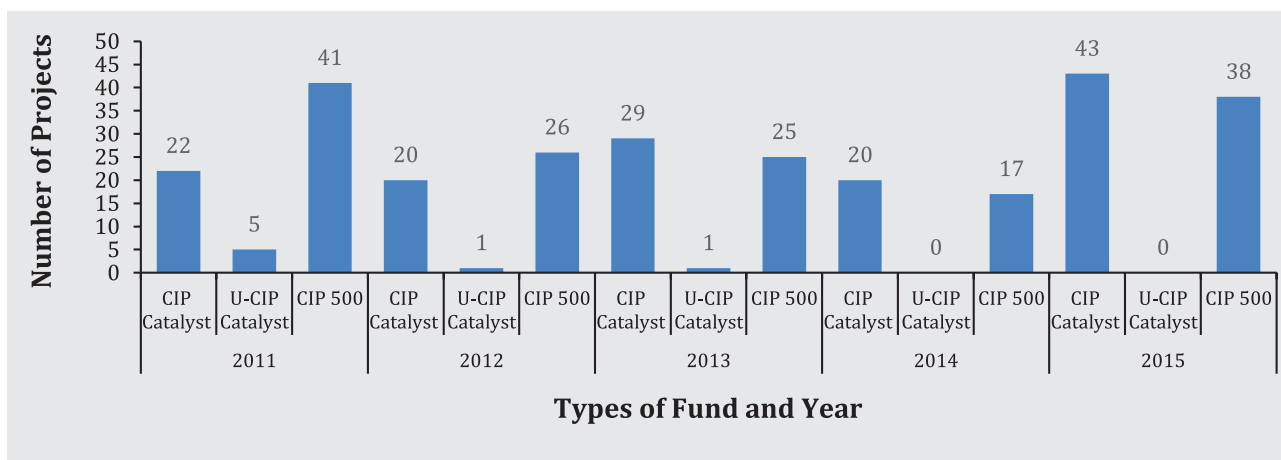
6.3.1 Pre-R&D Stage

a) Cradle Funds

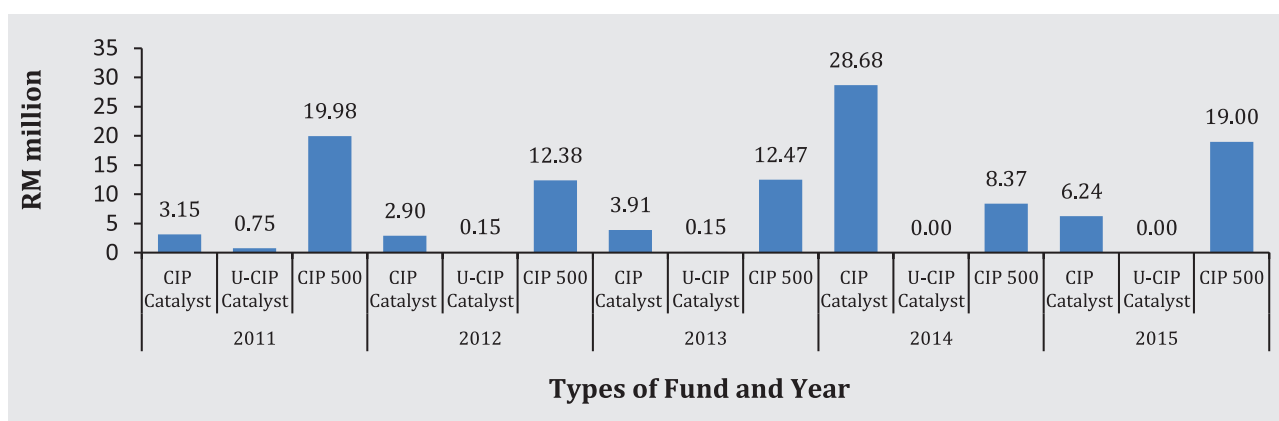
Cradle Fund Sdn. Bhd. is a not-for-profit agency under the purview of the Ministry of Finance Malaysia. Cradle hosts several Cradle Investment Programmes (CIPs) that aim to foster an ecosystem that supports a strong and innovative business oriented environment for technology entrepreneurs. These grants include CIP Catalyst, U-CIP Catalyst and CIP 500. CIP Catalyst and U-CIP Catalyst are conditional pre-seed funds; they aim to facilitate the transformation of innovative technology-based ideas and research outputs from teams of innovative individuals into commercially viable ventures. CIP Catalyst is for entrepreneurs in general, while U-CIP catalyst is for researchers, lecturers and students in local HLIs.

In the five year period of 2011 – 2015, Cradle approved 134 CIP Catalyst, 7 U-CIP Catalyst and 147 CIP 500 projects (Figure 6.2). The cumulative amounts approved were RM44.88 million, RM1.05 million and RM72.19 million respectively (Figure 6.3). The number of projects approved for CIP Catalyst was consistent throughout the period of 2011 – 2014, and the number doubled to 43 projects in 2015. The number of approved projects for CIP 500 declined from 2011 – 2014. However, the number of approved projects rebounded strongly to 38 projects in 2015. For U-CIP Catalyst, the number of approved projects was always low in comparison to the other two funds. Similar trend was observed in respect to the approved amount of funds.

Figure 6.2 Number of Projects Approved, Cradle Funds, 2011 – 2015



Source : Cradle Fund Sdn. Bhd.

Figure 6.3 Amount of Projects Approved, Cradle Funds, 2011 – 2015

Source : Cradle Fund Sdn. Bhd.

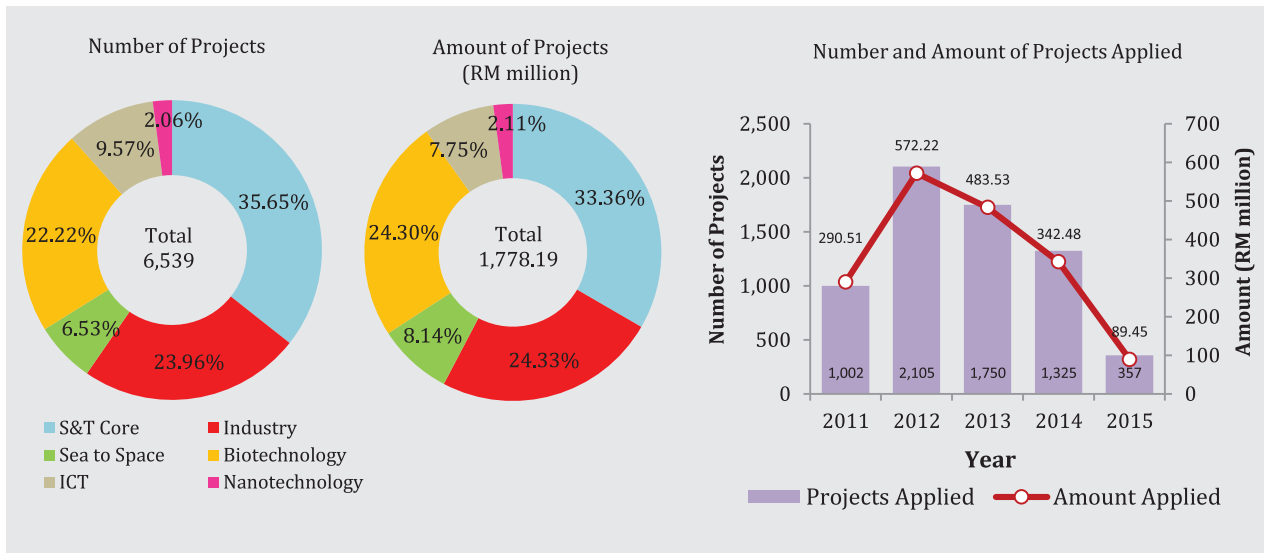
6.3.2 Research Stage

a) ScienceFund

ScienceFund supports R&D projects that can contribute to the discovery of new ideas and the advancement of knowledge in applied sciences, focusing on high impact and innovative research. The grant covers R&D activities ranging from basic or fundamental strategic research and applied science, to the development of laboratory-scale prototypes. ScienceFund focuses on five main clusters, namely: S&T Core; Industry; Sea to Space; Biotechnology; ICT; and Nanotechnology. ScienceFund is open to all researchers, scientists and engineers employed on a permanent or contractual basis in GRIs, Government STI Agencies, and Public and Private HLIs with accredited research programmes.

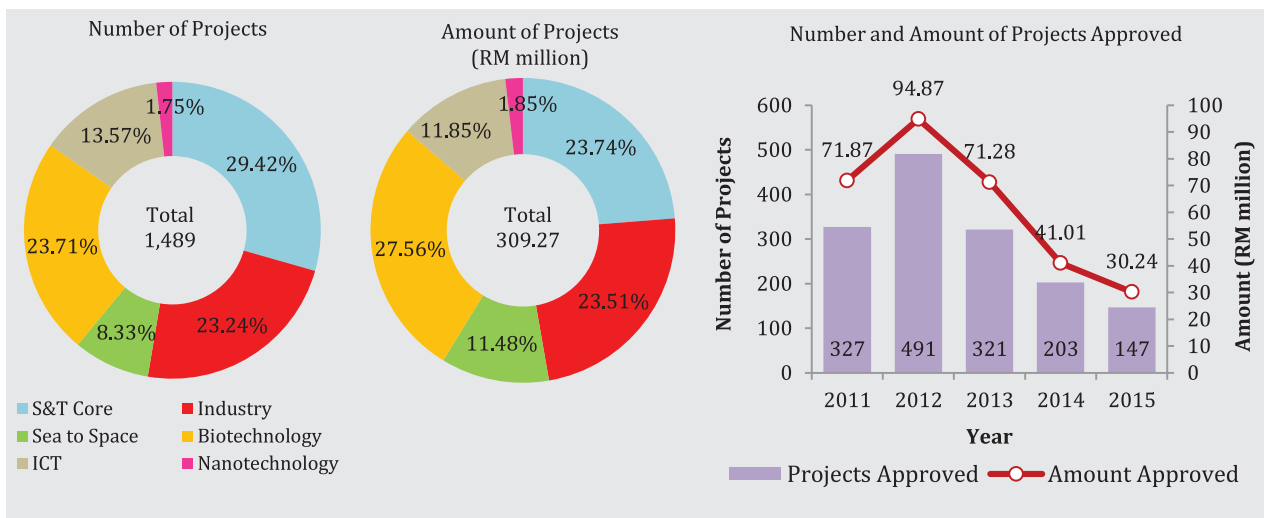
A total of 6,539 project applications amounting to RM1,778.19 million were received by MOSTI in 2011 – 2015. Given that 1,489 applications valued at RM309.27 million were approved, the approval rates were 22.77% and 17.39% for the number and amount of projects, respectively (Figure 6.4 and Figure 6.5). The highest number and amount of applied and approved projects were recorded in 2012. However, this number and amount decreased drastically during 2013 – 2015. Out of the total number of approved projects, S&T Core cluster shared the highest portion with 438 projects (29.42%). These were followed by Biotechnology cluster with 353 projects (23.71%) and Industry cluster with 346 projects (23.24%). In terms of the total approved amount, Biotechnology cluster received the highest funding with RM85.23 million (27.56%). This was followed by S&T Core cluster with RM73.43 million (23.74%) and Industry cluster with RM72.72 million (23.51%). Overall, S&T Core, Industry and Biotechnology were the main three clusters with the largest number and amount of projects (Figure 6.6 and Figure 6.7).

Figure 6.4 Number and Amount of Projects Applied, ScienceFund, 2011 - 2015



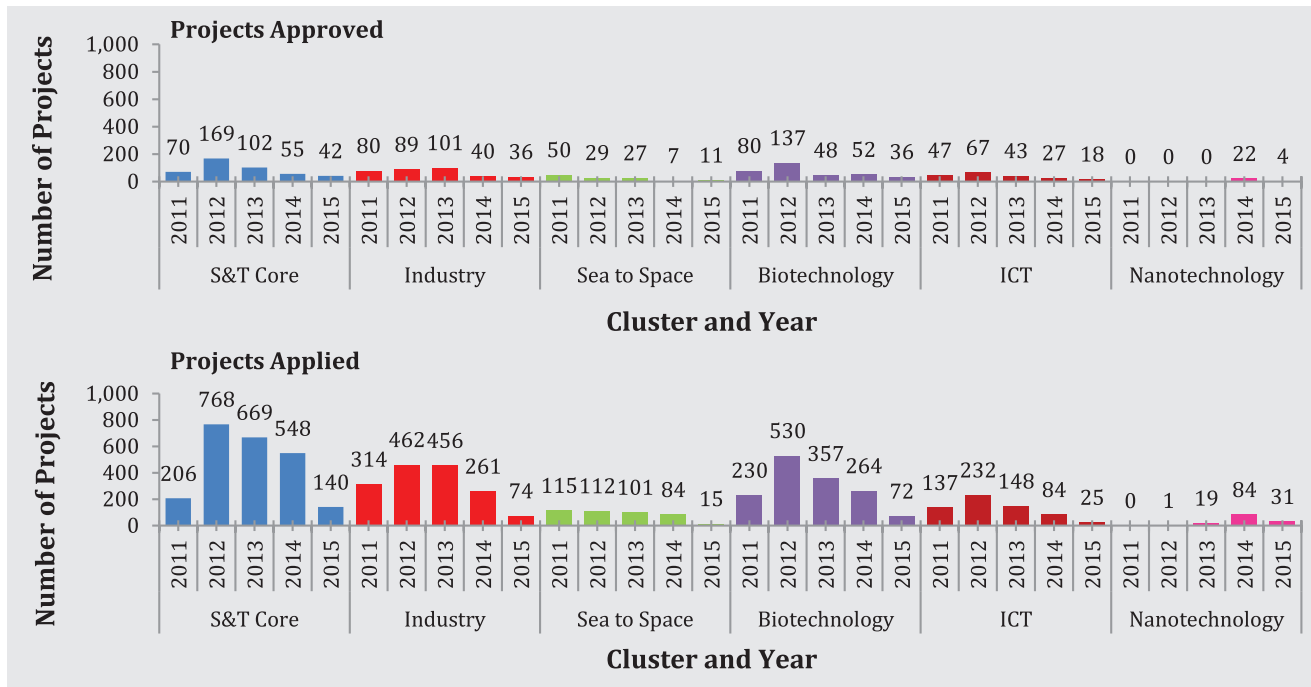
Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.5 Number and Amount of Projects Approved, ScienceFund, 2011 - 2015



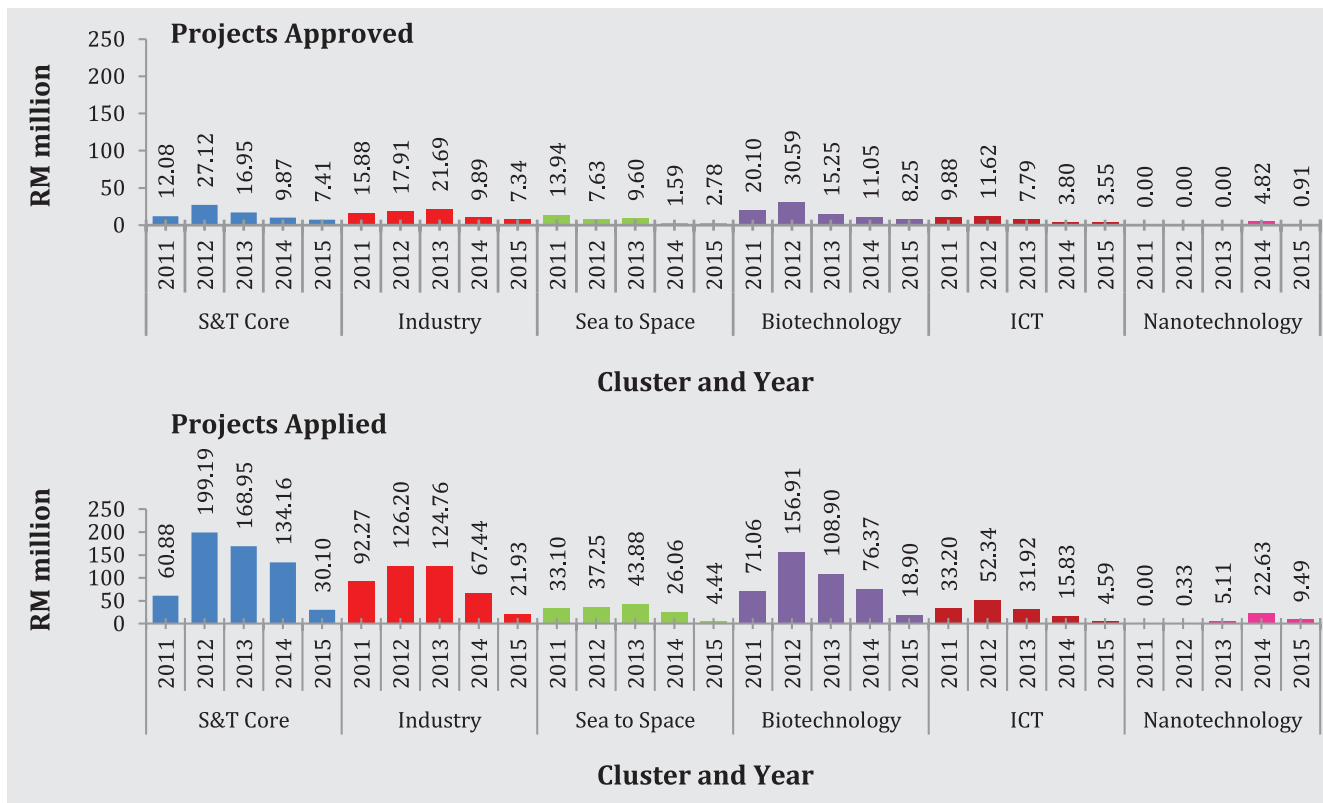
Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.6 Applied and Approved Projects by Cluster, ScienceFund, 2011 – 2015



Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.7 Amount of Applied and Approved Projects by Cluster, ScienceFund, 2011 – 2015



Source : Ministry of Science, Technology and Innovation Malaysia

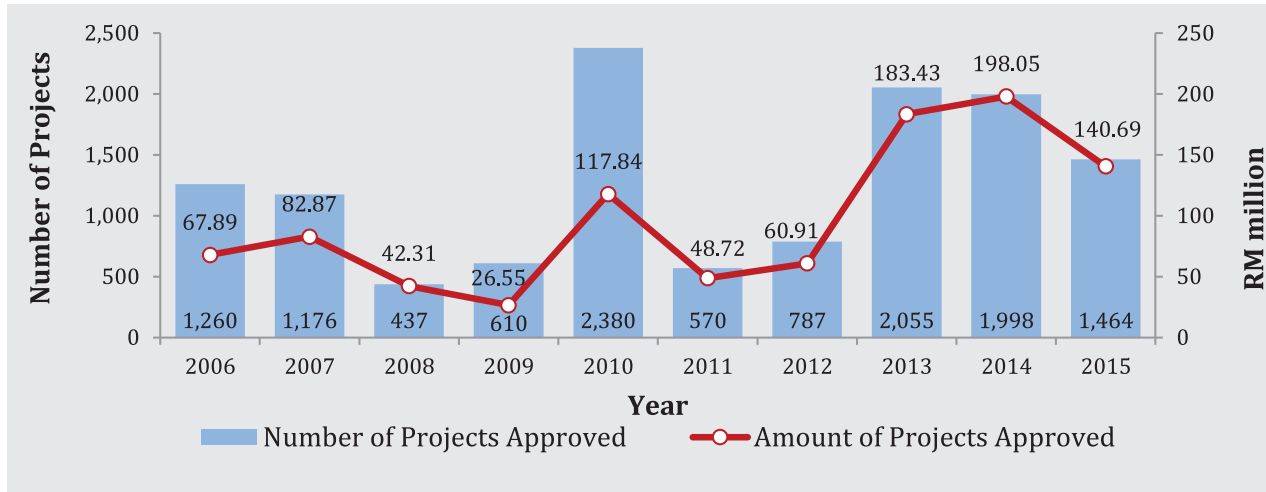
b) Grant Schemes by MOHE

MOHE has initiated several research grants that cover basic and applied research projects in order to enhance, promote and support the research activities among academic staff, in both public and private HLIs. These include:

- Fundamental Research Grant Scheme (FRGS) that aims to encourage the generation of new theories, concepts and ideas that catalyse new discoveries, and innovative inventions for knowledge enhancement.
- Exploratory Research Grant Scheme (ERGS) that seeks to encourage inquisitive minds, explore new ideas and concepts that can be catalysts for new discoveries, and inventions that can expand the boundaries of innovative knowledge.
- Long Term Research Grant Scheme (LRGS) that involves longitudinal studies aimed at generating new theories and ideas in the forefront of strategic niche areas, for expanding the boundaries of knowledge.
- Prototype Research Grant Scheme (PRGS) that assists prototype development and bridges the gap between laboratory or research findings and pre-commercialisation.
- Research Acculturation Grant Scheme (RAGS) that acts as a seed fund for acculturating research activities among young researchers at the non-research public HLIs, in order to enhance their research performance and develop their ability to compete locally and internationally.
- Research Acculturation Collaborative Effort (RACE) that serves as a new initiative to mobilise collaborative efforts between research universities and non-research universities.

FRGS is the main grant administrated by MOHE. In the 9th Malaysia Plan (2006 – 2010), 5,863 projects were approved amounting to RM337.45 million. During the five years of the 10th Malaysia Plan (2011 – 2015), a total of 6,874 projects amounting to RM631.80 million were given out by MOHE to the respective researchers (Figure 6.8). This translates to an increase of 17.24% in number of approved projects, and an 87.23% increase in the amount of projects approved. The highest number of approved projects was recorded in 2010 with 2,380 projects. In terms of approved amounts, the highest amount was in 2014 with RM198.05 million. A significant decline was observed in both number and amount of approved projects under FRGS in year 2015.

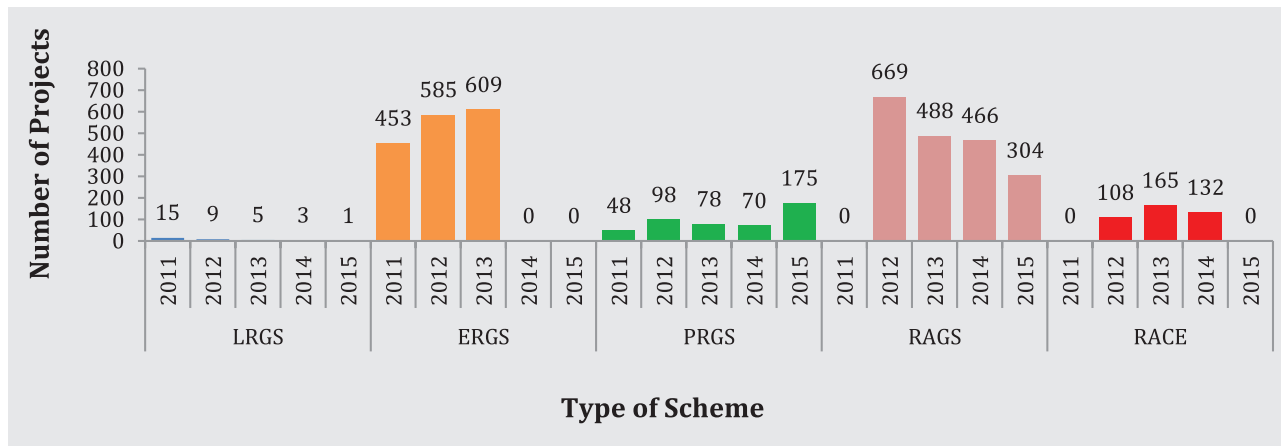
Figure 6.8 Number and Amount of Approved Projects, FRGS, 2006 – 2015



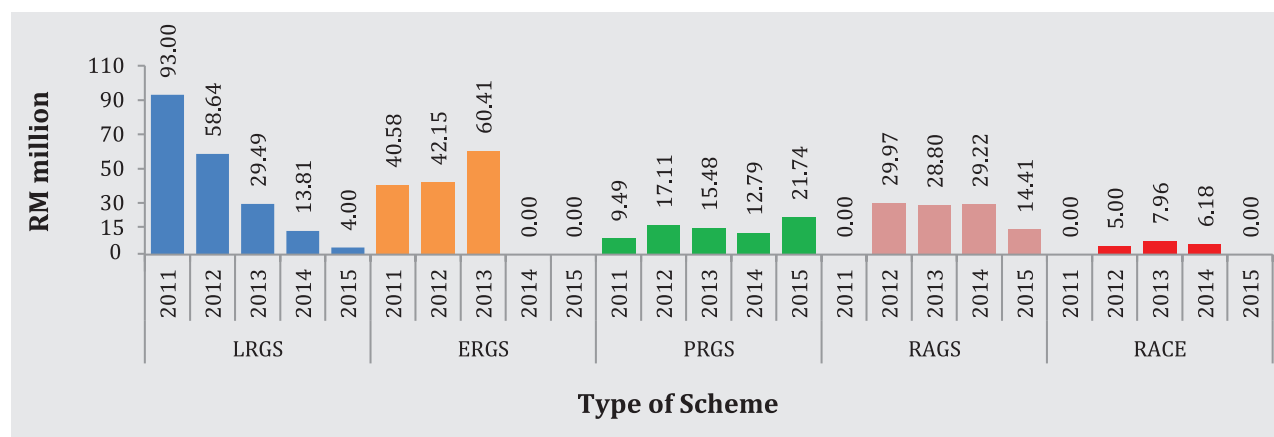
Source : Ministry of Higher Education Malaysia

Figure 6.9 and Figure 6.10 exhibit the performance of the other five grants under MOHE, namely LRGS, ERGS, PRGS, RAGS and RACE. Both ERGS and RAGS have a higher number of approved projects than PRGS, RACE and LRGS. LRGS projects received a higher amount of grants in the first two years of the 10th Malaysia Plan. However, the approved amount of grants reduced drastically, corresponding to the decline in number of approved projects in 2013 – 2015. The amount of grants received by ERGS, PRGS, RAGS and RACE also show some inconsistencies, corresponding to the number of approved projects for the respective grants.

Figure 6.9 Number of Approved Projects, MOHE, 2011 – 2015



Source : Ministry of Higher Education Malaysia

Figure 6.10 Amount of Approved Projects, MOHE, 2011 – 2015

Source : Ministry of Higher Education Malaysia

6.3.3 Development Stage

a) TechnoFund

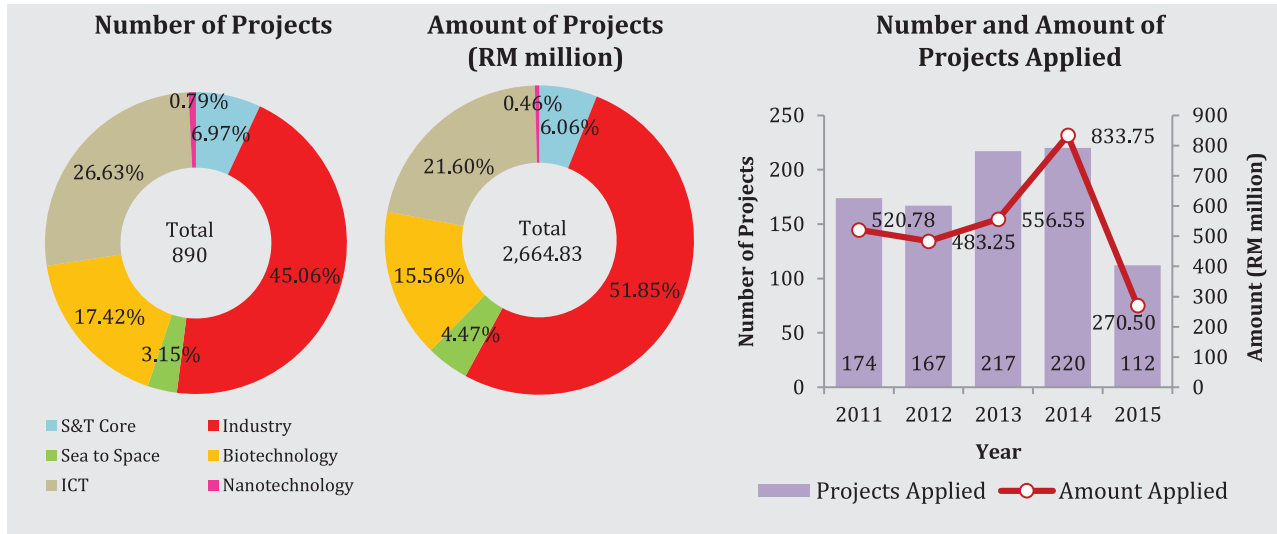
TechnoFund aims to stimulate the growth and successful innovation of Malaysian enterprises by providing funding for technology development up to the pre-commercialisation stage. Eligible applicants can be researchers and other individuals from SMEs, HLIs, GRIs, and STI agencies. Companies must have a minimum of 51% equity held by Malaysians.

During 2011 – 2015, a total of 890 applications with a cumulative amount of RM2,664.83 million was received by MOSTI for TechnoFund. Out of this amount, MOSTI granted 113 projects amounting to RM212.05 million (Figure 6.11 and Figure 6.12). The approval rate stood at 12.70% and 7.96% for number and amount of projects, respectively. The number of approved projects was rather consistent over the five years, ranging from 19 to 27 projects annually. The number and amount of approved projects were always in an upward trend, except for 2014 witnessing a slight decline. The highest number and amount approved were recorded in 2015, with 24 projects that amounted to RM57.83 million.

Out of the total number of approved projects, more than half the projects were in the Industry cluster with 65 projects (57.52%). This was followed by ICT cluster with 19 projects (16.81%) and Biotechnology cluster with 14 projects (12.39%). In terms of total amounts granted for projects, the Industry cluster dominated with 60.65% of the total allocations. This was followed by Biotechnology cluster (12.09%) and ICT cluster (11.06%). Nonetheless, a clear declining trend is observed in terms of applied projects in 2015 (Figure 6.11). On the contrary, the number of approved projects was consistently in the range of 24-27 during the same period, and the approved amount also reached a new milestone in 2015 with RM57.83 million (Figure 6.12). Overall, the Industry cluster leads the annual applications

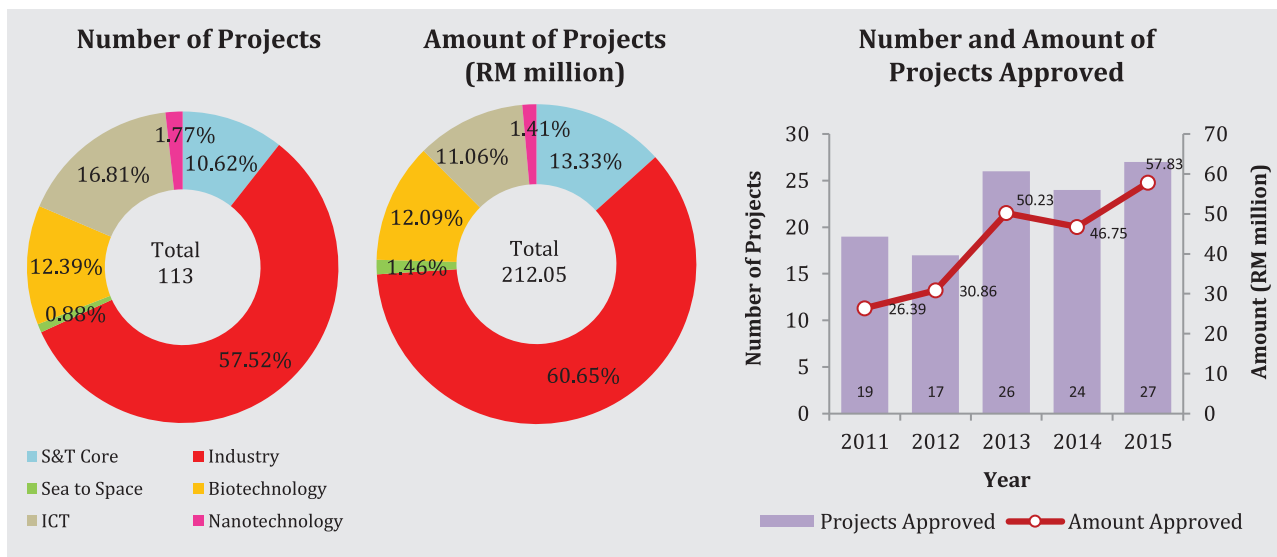
and approvals in both the number and amount of projects during 2011 – 2015 (Figure 6.13 and Figure 6.14).

Figure 6.11 Number and Amount of Projects Applied, TechnoFund, 2011 – 2015



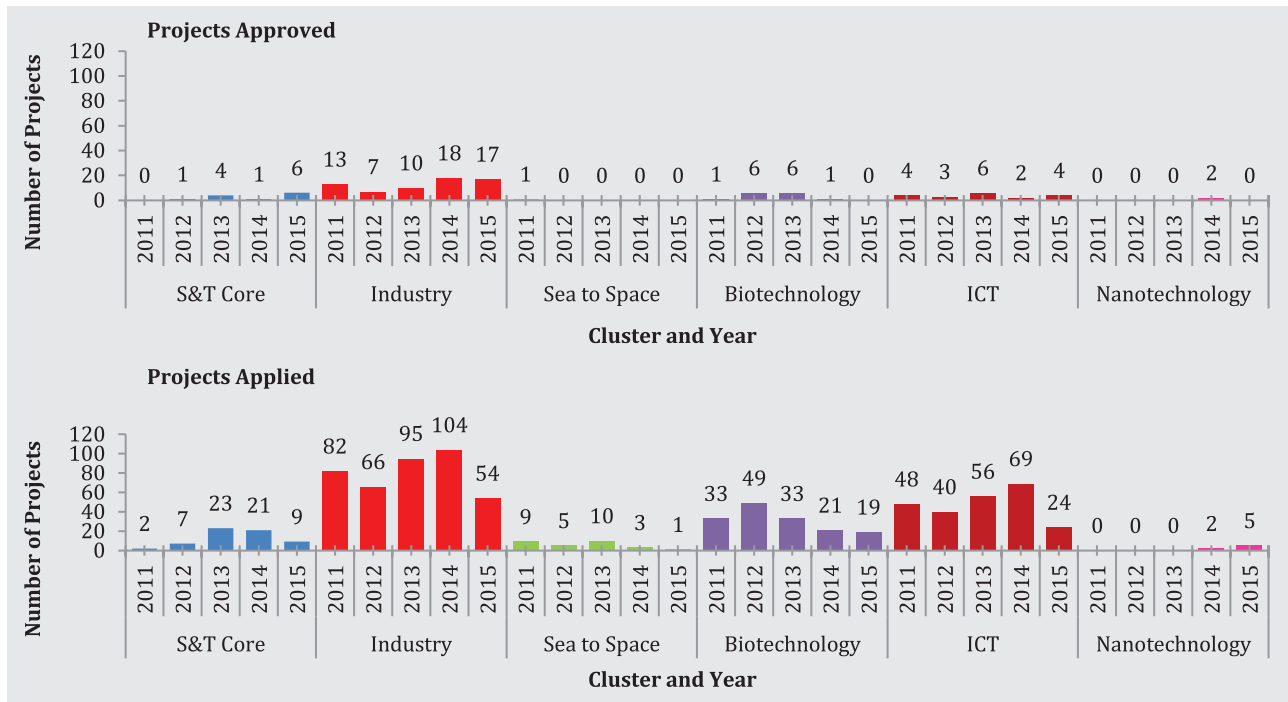
Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.12 Number and Amount of Projects Approved, TechnoFund, 2011 – 2015



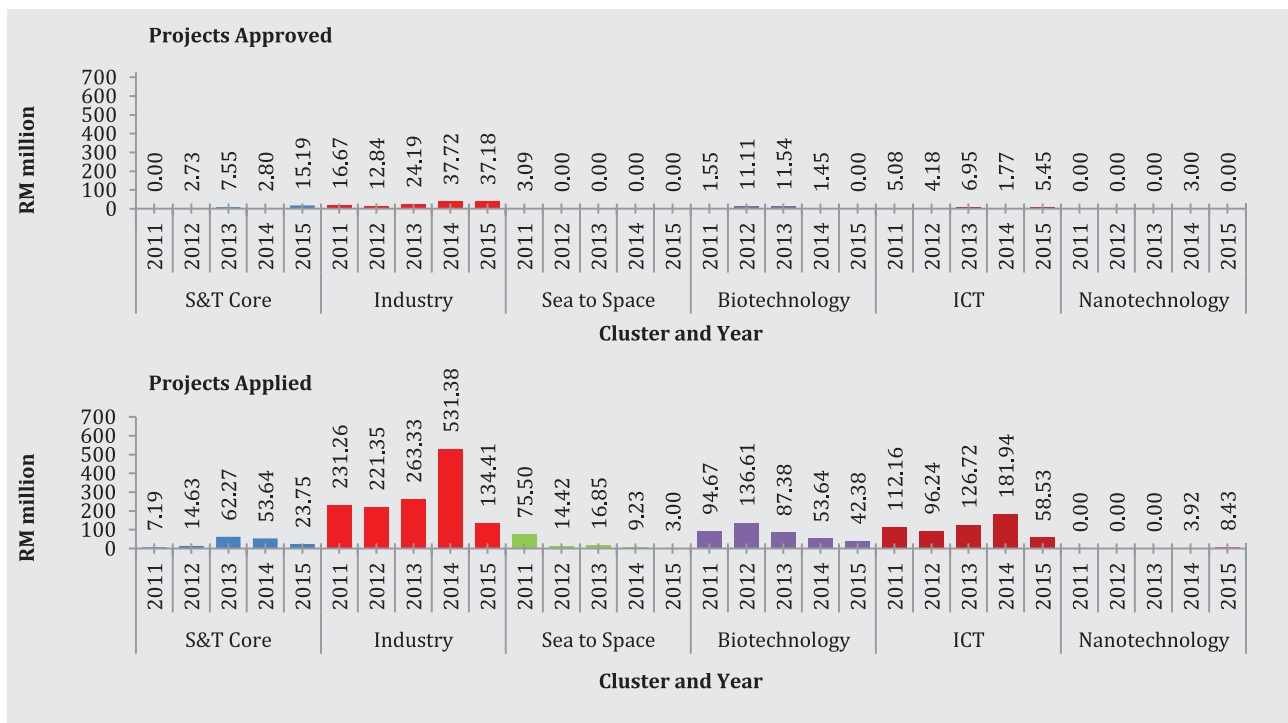
Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.13 Number of Projects Applied and Approved by Clusters, TechnoFund, 2011 - 2015



Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.14 Amount of Projects Applied and Approved by Clusters, TechnoFund, 2011 - 2015



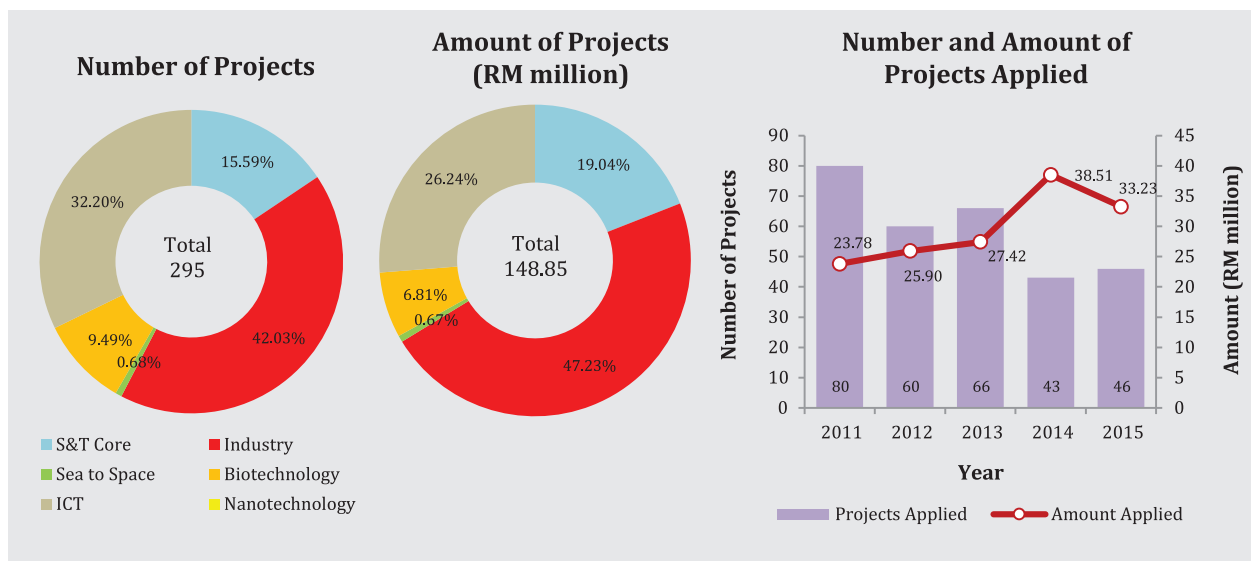
Source : Ministry of Science, Technology and Innovation Malaysia

b) InnoFund

InnoFund is a pre-commercialisation fund administered by MOSTI that aims to increase the participation of micro-businesses and individuals in innovative activities, as well as encourage technological innovation of new or existing products, processes or services for commercialisation. Besides, the project must have economic value and improve the societal well-being of the community. InnoFund can be categorised into Enterprise InnoFund (EIF) and Community InnoFund (CIF).

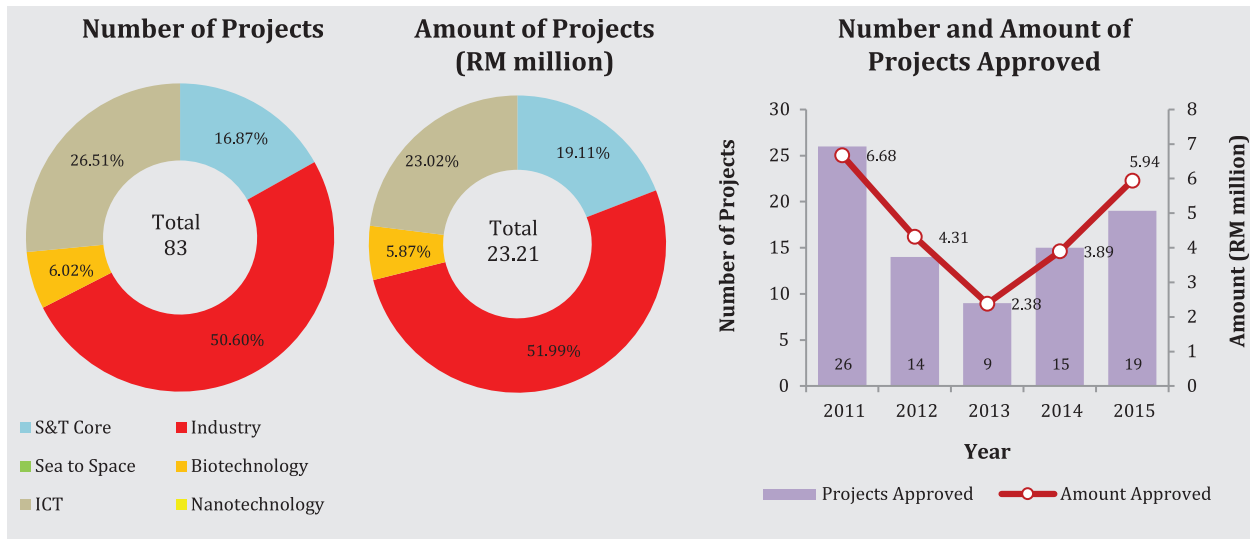
During 2011 – 2015, MOSTI received a total of 295 InnoFund applications with a cumulative amount of RM148.85 million. Of these, 83 projects were granted with a total allocation of RM23.21 million. The success rate was 28.14% and 15.59% in terms of number and amount of projects respectively (Figure 6.15 and Figure 6.16). In general, the number of applications recorded a decline over this period, i.e. nearly halved from 80 projects in 2011, to only 46 projects in 2015. On a positive note, the number of approved projects exhibited an upward trend since 2013. A similar trend was seen in terms of the total approved amounts during the same period. Half of the total number of approved InnoFund projects were in the Industry cluster (50.60%), followed by ICT cluster (26.51%) and S&T Core cluster (16.87%). A similar trend was observed in terms of the amounts of approved projects where the Industry cluster was clearly ahead of other clusters (Figure 6.17 and Figure 6.18).

Figure 6.15 Number and Amount of Projects Applied, InnoFund, 2011 – 2015



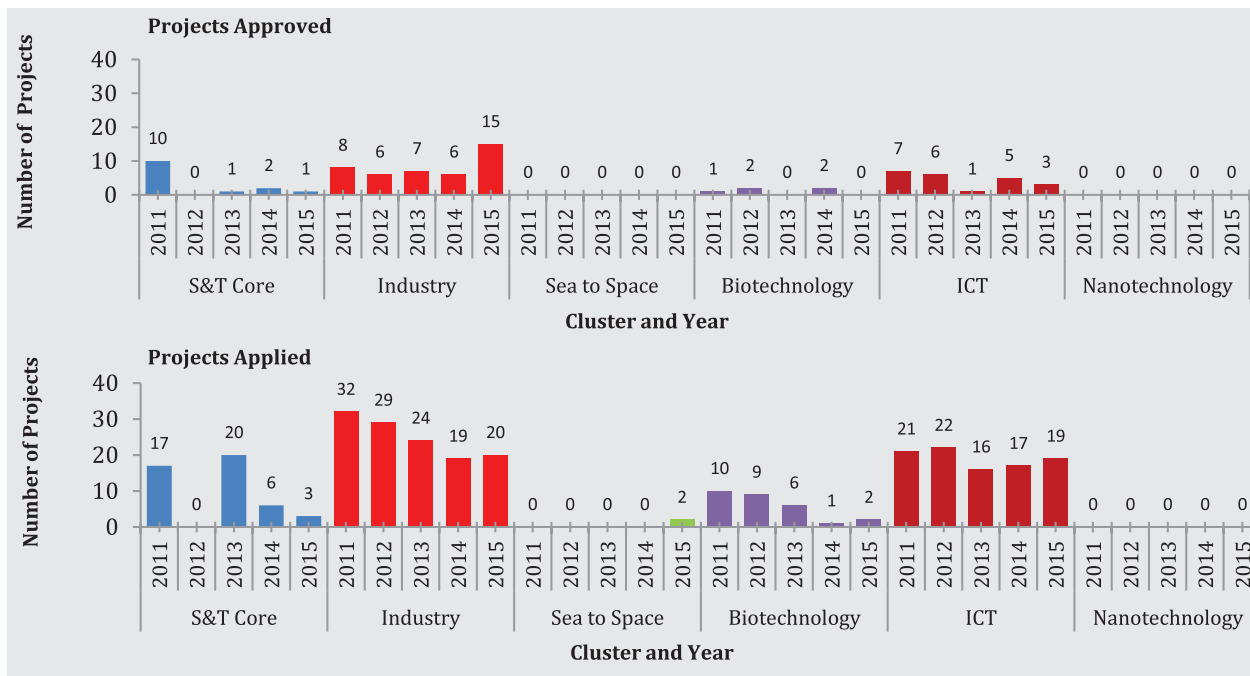
Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.16 Number and Amount of Projects Approved, InnoFund, 2011 - 2015



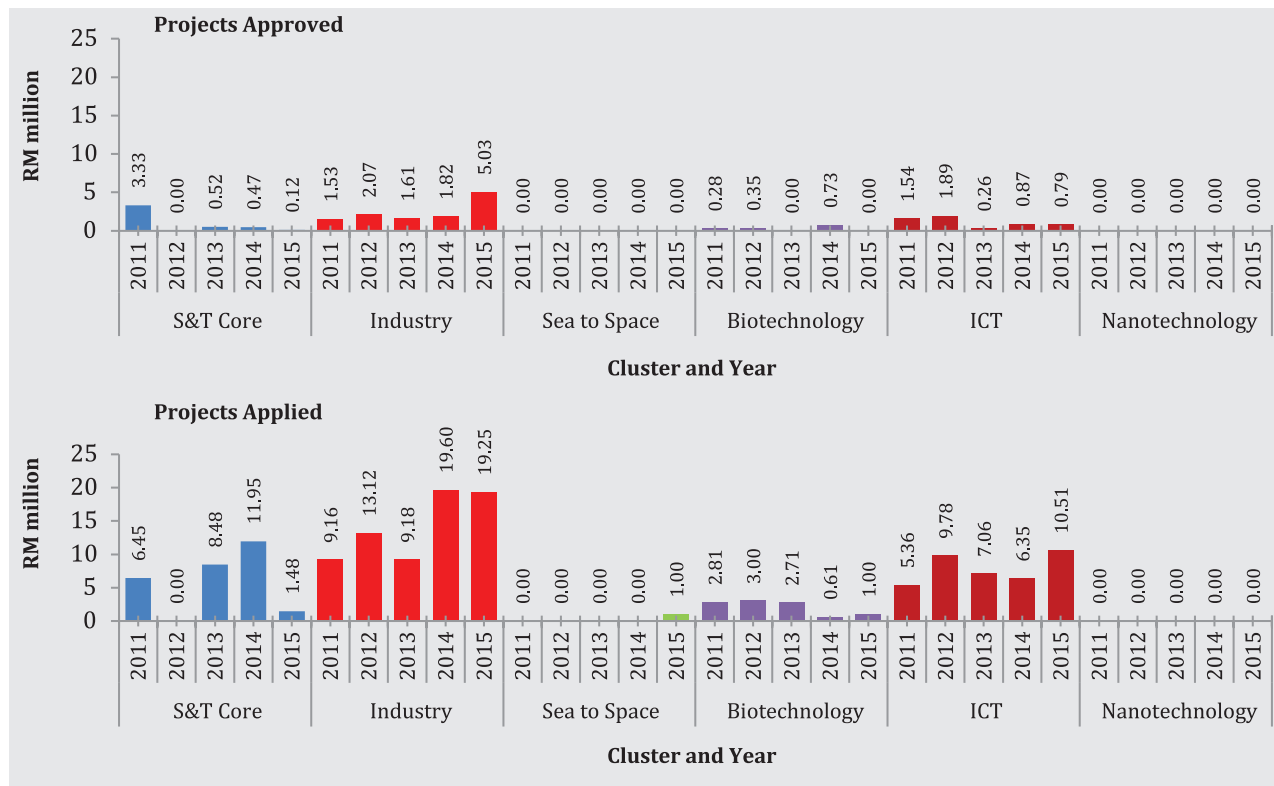
Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.17 Number of Projects Applied and Approved by Clusters, InnoFund, 2011 - 2015



Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.18 Amount of Projects Applied and Approved by Clusters, InnoFund, 2011 – 2015



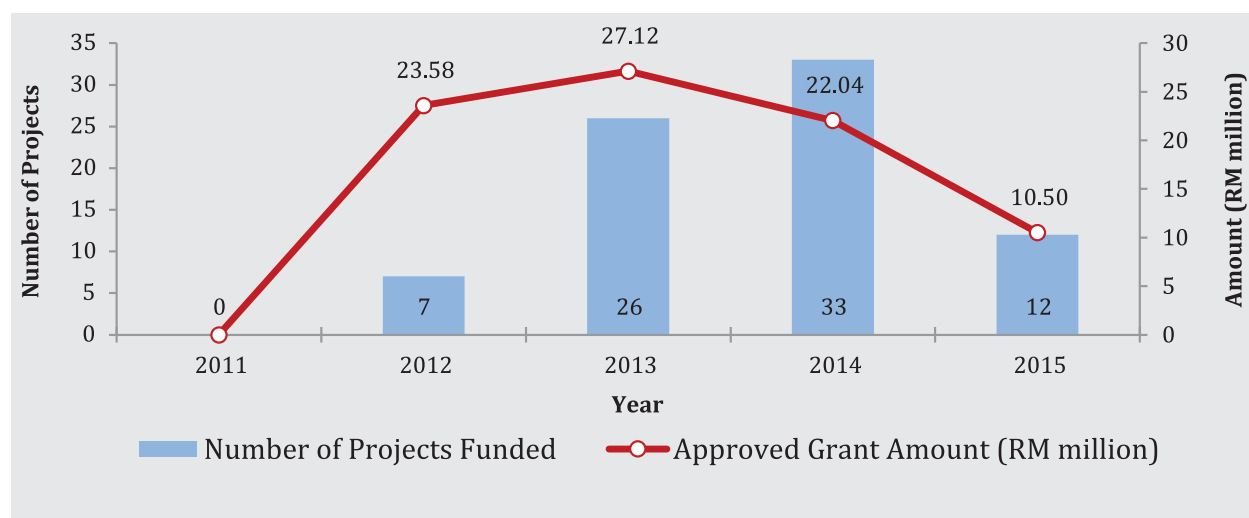
Source : Ministry of Science, Technology and Innovation Malaysia

c) MAC3 Fund

MSC Malaysia (formerly known as the Multimedia Super Corridor Malaysia) is a Government initiative to groom local industries and to promote world class ICT based companies. In this respect, the Government established the MAC3 (or MSC Malaysia Animation Creative Content Centre) Fund to provide financial support to innovative local companies aiming to develop, produce and co-produce content in the creative industry in Malaysia. Prior to 2013, the fund was named the MAC3 Co-Production fund. In 2013, the fund was rebranded as the MAC3 Fund that encompassed three types of activities, namely: development; production; and co-production. Activities covered under the MAC3 Fund include, among others: Animation; Game; Digital Film with VFX components; Beyond Entertainment (Education, Simulation and Training content); and High-end Technology Deployment (Film Technology, Editing and Colouring, Digitalisation) that will contribute to the overall development of the creative multimedia industry and MSC Malaysia. The MAC3 Fund is managed by MDEC Malaysia.

A total of 78 projects amounting to RM83.23 million were approved during 2011 – 2015 (Figure 6.19). The number of approved projects reached 33 in 2014, which was the highest in the five-year period. However, there was a sharp drop in the number of approved projects in 2015. In terms of amounts of approved projects, the highest amount was recorded in 2013 with RM27.12 million. The amounts of approved projects showed a significant downward trend in 2015, with a decrease of 61.28% from 2013.

Figure 6.19 Number and Amount of Projects Approved, MAC3 Fund, 2011 – 2015



Source : Malaysia Digital Economy Corporation

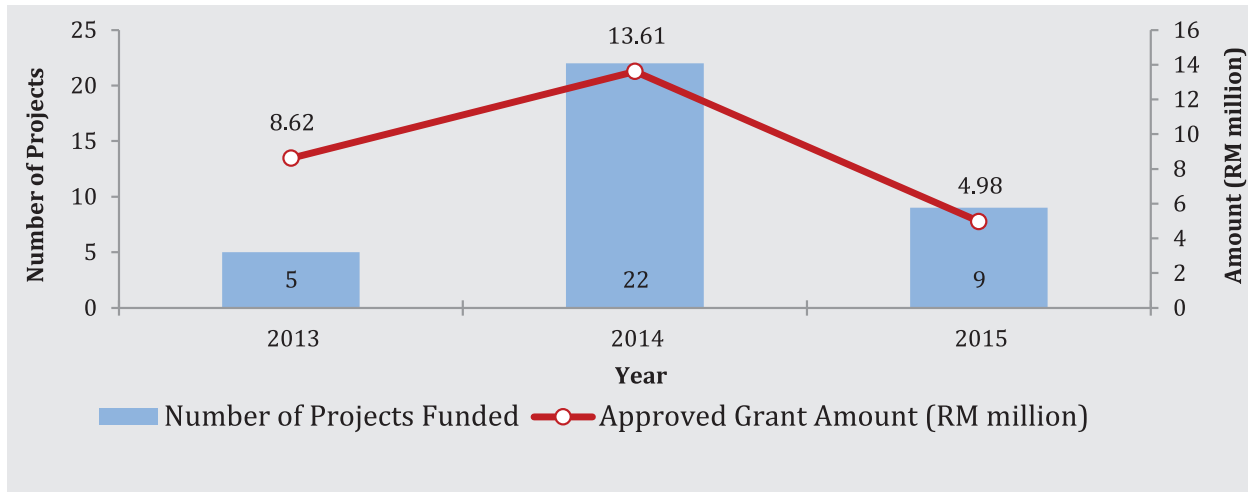
The approved projects delivered 28 IPs during 2011 – 2015. A snapshot of the successful projects are as follows:

- *Ejen Ali* – The project received co-investment from Media Prima to produce an animation series. This animated series is currently aired on TV3.
- *Pumpkin Reports* – This animated cartoon was nominated as the “Best TV Series for Kids” and received the Cartoons on the Bay 2015 Pulcinella Award in Venice. This animated series is currently aired on Cartoon Network, France.
- *Chuck Chicken* – This animated series is currently aired on Nickelodeon Southeast Asia, Disney Asia, and Disney China.
- *Origanimals* – This 3D animated series is currently aired on Zoomo Channel that covers 27 countries, including Astro Malaysia.

d) BCi2 Fund

BCi2 (or Bumiputera Content Industry Initiative) is another fund administered by MDEC. The fund has been established since 2009 in order to strengthen the performance and global competitiveness of Bumiputera companies in the ICT industry. There were no BCi2 funds granted in 2011 and 2012. During 2013 – 2015, a total of 36 projects with RM27.21 million was approved by MDEC (Figure 6.20). About 61.11% of the total number of approvals were registered in 2014 with a sum of RM13.61 million, the highest over the period. There was a sharp drop in the number as well as the amount of approved projects in 2015. As of 2015, these approved projects have filed for 45 IPs.

Figure 6.20 Number and Amounts of Projects Approved, BCi2 Fund, 2013 – 2015



Source : Malaysia Digital Economy Corporation

Among the successful projects are:

- *“Boboiboy the Movie”* from *Animonsta Studios Sdn. Bhd.* – The movie managed to collect RM16 million in revenue and is considered a box office hit.
- *“Didi & Friends”* from *DD Animation Studio Sdn. Bhd.* – These nursery sing-along rhymes received 42 million views on their Youtube Channel. The company is currently working with Astro to produce a 26-episode animated series.

6.3.4 Commercialisation Stage

a) Commercialisation of R&D Fund (CRDF)

CRDF is administrated by the Malaysian Technology Development Corporation (MTDC) to fund commercialisation activities of locally developed technologies undertaken by Malaysian owned companies. The technologies can be those developed by the public sector, or they can also be the output of in-house research and development (R&D) activities by companies. In 2011 – 2015, a sum of 100 CRDF projects worth RM174,049,000 was granted (Table 6.1). The project sectors of Industrial Products (24.79%), Biotechnology (19.10%) and Advanced Materials (9.58%) were the three main sectors that received the most funding in terms of approved amounts. The number of approved projects gradually decreased from 28 projects (with RM52,867,000) in 2011, to 14 projects (with RM27,234,000) in 2015 (Figure 6.21). As a whole, the total number and value of approved projects fluctuated over the years. The year 2011 recorded the highest amount of approved CRDF projects, whereas the lowest amount was recorded in the year 2014.

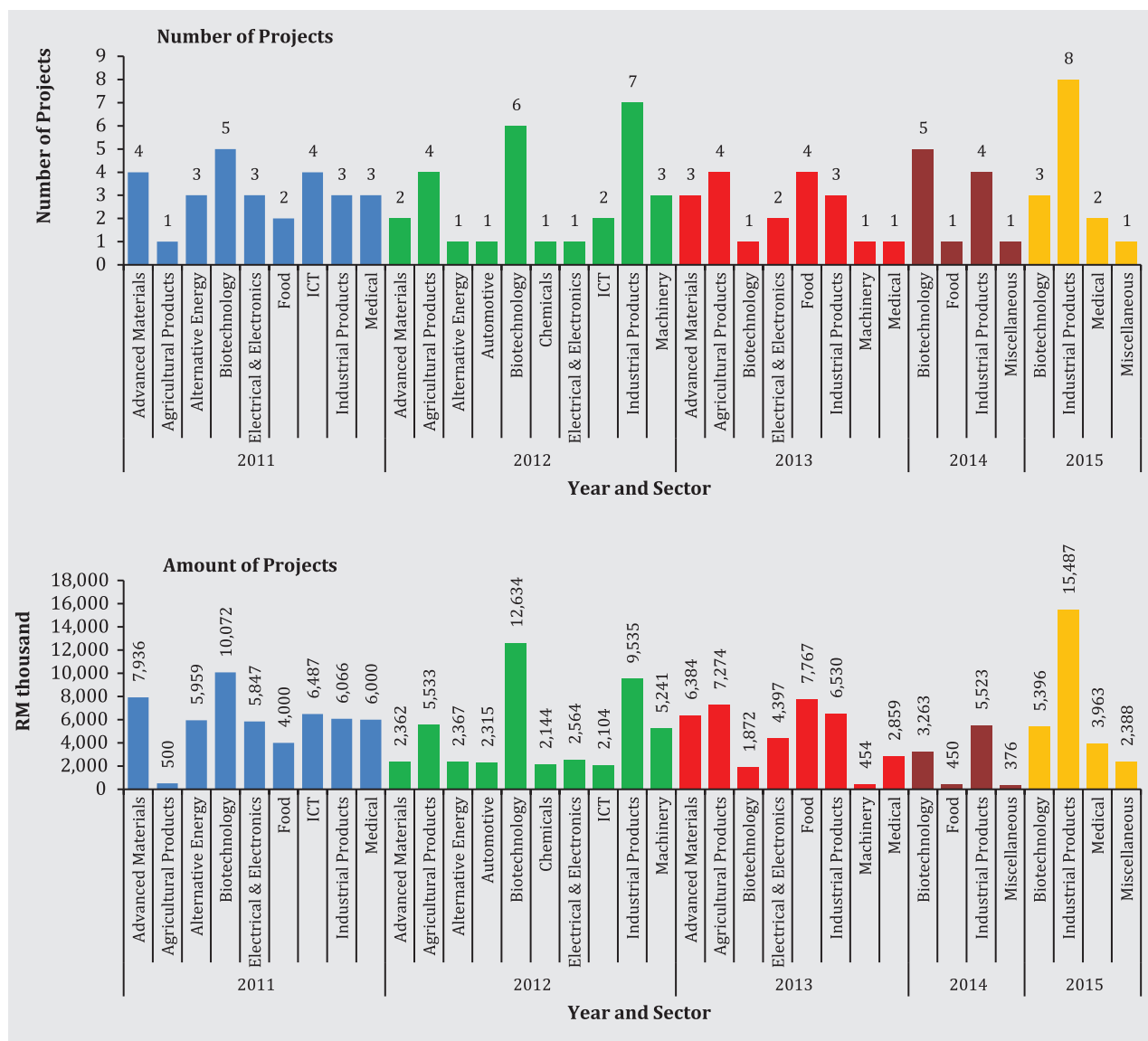
Table 6.1 Number and Amount of Approved CRDF Projects by Sector, 2011 - 2015

Project Sector	Approved Projects		Approved Amount	
	No.	Percentage	RM thousand	Percentage
Advanced Materials	9	9	16,682	9.58
Agricultural Products	9	9	13,307	7.65
Alternative Energy	4	4	8,326	4.78
Automotive	1	1	2,315	1.33
Biotechnology	20	20	33,237	19.10
Chemicals	1	1	2,144	1.23
Electrical & Electronics	6	6	12,808	7.36
Food	7	7	12,217	7.02
ICT	6	6	8,591	4.94
Industrial Products	25	25	43,141	24.79
Machinery	4	4	5,695	3.27
Medical	6	6	12,822	7.37
Metal Based	0	0	0	0.00
Miscellaneous	2	2	2,764	1.59
Pharmaceutical	0	0	0	0.00
Recycle-Based	0	0	0	0.00
Sand & Mineral Based	0	0	0	0.00
TOTAL	100	100	174,049	100.00

Note : The list includes companies with grants that have been revoked. 3 companies which were approved in 2016 under the 10th Malaysia Plan are included in the list. MTDC's list of companies that applied does not include the sectors they are in.

Source : Malaysian Technology Development Corporation

Figure 6.21 Number and Amount of Approved CRDF Projects, 2011 – 2015



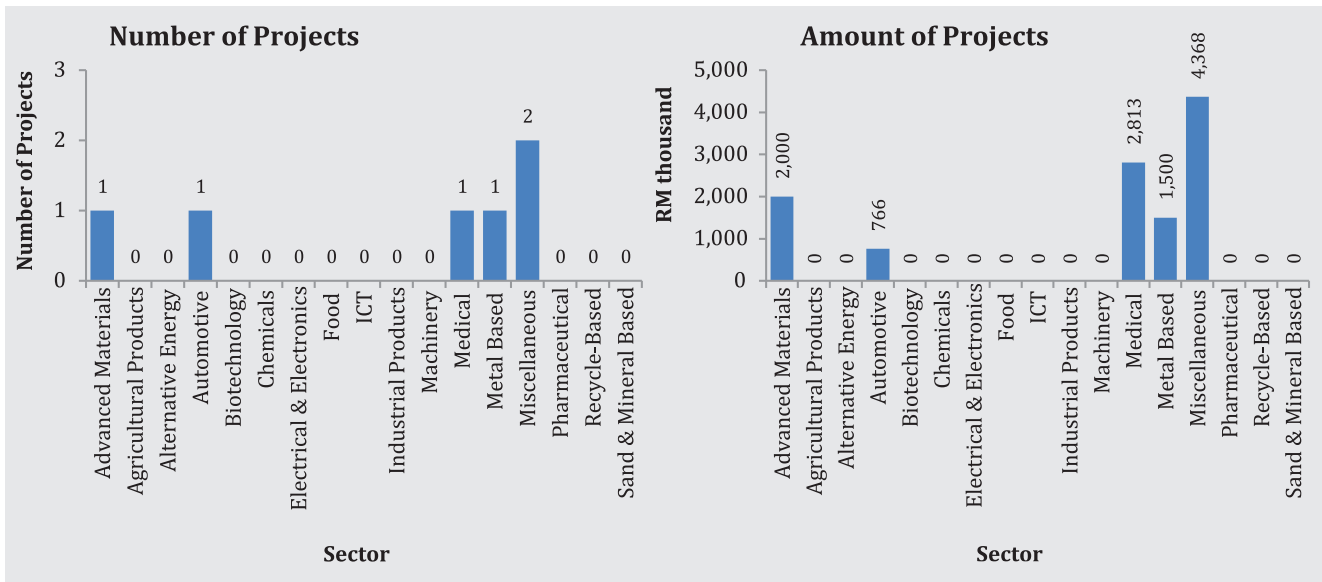
Note : The list includes companies with grants that have been revoked. 3 companies which were approved in 2016 under the 10th Malaysia Plan are included in the list. MTDC's list of companies that applied does not include the sectors they are in. Only sectors with approved projects are shown in the figure.

Source : Malaysian Technology Development Corporation

b) Technology Acquisition Fund (TAF)

TAF aims to facilitate eligible Malaysian companies in the acquisition of foreign technologies for immediate incorporation into the company's manufacturing activity. The acquisition of technology could be in the form of acquiring know-how / IP exploitation / rights / blueprints, via licensing of technology or outright purchase of technology. A small number of TAF projects, i.e. 6 projects amounting to RM11,447,000 were approved in 2011 – 2015 (Figure 6.22). The sectors that received TAF grants were Advanced Materials, Automotive, Medical, Metal Based, and Miscellaneous.

Figure 6.22 Number and Amount of Approved TAF Projects, 2011 - 2015

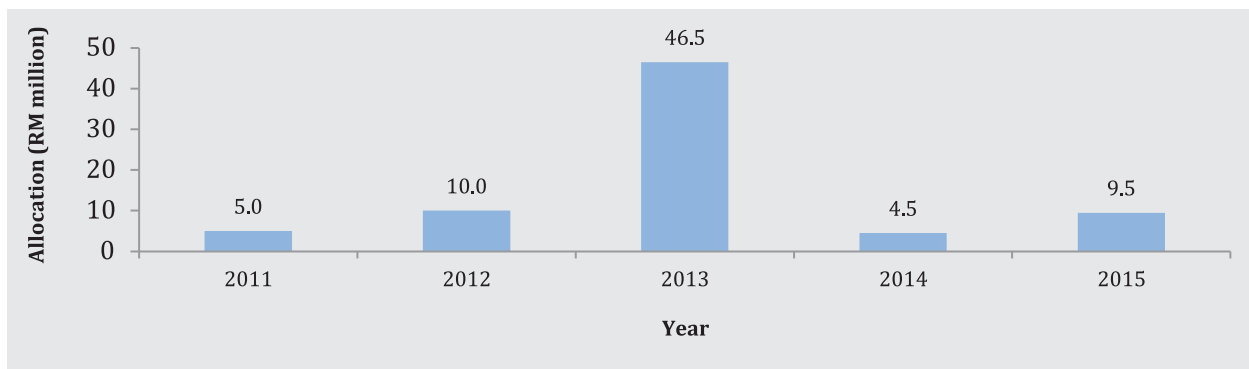


Source : Malaysian Technology Development Corporation

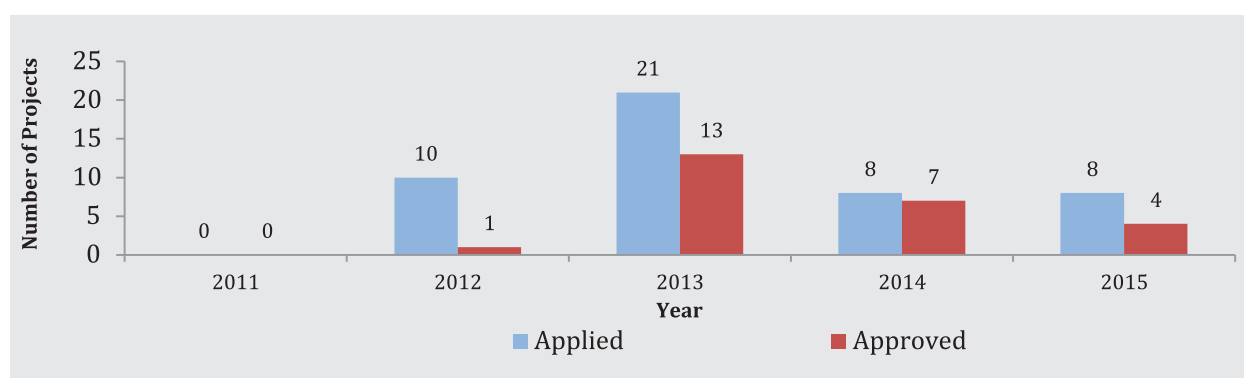
c) Biotechnology Commercialisation Fund (BCF)

BCF is a new funding assistance programme introduced under the 10th Malaysia Plan in order to further boost the growth of BioNexus Status companies in Malaysia. The key objectives of BCF are to facilitate on-going commercialisation of biotechnology products and services, and to facilitate expansion of existing biotechnology businesses. In general, BCF is a term loan/financing facility that is offered based on conventional principles, primarily for the financing of working capital and capital expenditure. BCF is managed by BiotechCorp. A total of RM75.5 million was allocated for BCF during the 10th Malaysia Plan. The highest allocation of funds was recorded in 2013 with RM46.5 million (Figure 6.23). BiotechCorp received 47 applications during the five year period 2011 - 2015. Out of these applications, 25 projects or 53.19% were approved with a total amount of RM71.7 million (Figure 6.24 and Figure 6.25).

Figure 6.23 Total Allocation for BCF, 2011 - 2015

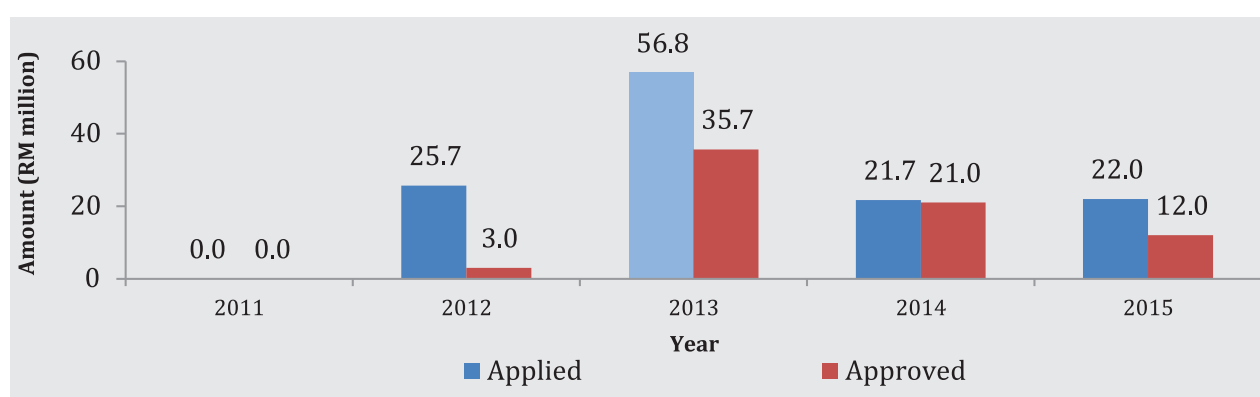


Source : BiotechCorp Malaysia

Figure 6.24 Number of Projects Applied and Approved, BCF, 2011 – 2015

Note : One approved company in 2013 withdrew from the programme. The number of companies approved in 2013 has been reduced to 12 (RM32.7 million).

Source : BiotechCorp Malaysia

Figure 6.25 Amount of Projects Applied and Approved, BCF, 2011 – 2015

Note : One approved company in 2013 withdrew from the programme. The number of companies approved in 2013 has been reduced to 12 (RM32.7 million).

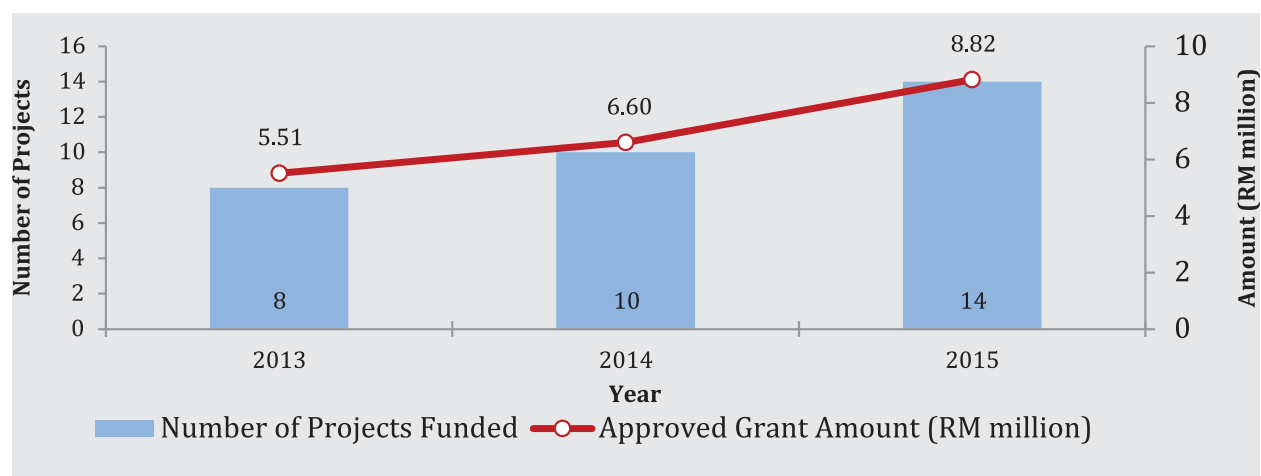
Source : BiotechCorp Malaysia

d) Product Development and Commercialisation Fund (PCF)

PCF assists local MSC companies to accelerate the development and commercialisation of innovative and market driven products, solutions or services as well as increasing the creation of intellectual property for commercialisation. PCF is a continuation of the MSC Malaysia R&D Grant Scheme (MGS) which was discontinued in 2013. The fund is managed by MDEC and focuses on eight main fields of technology, namely: security; e-commerce; big data analytics; Internet of Things (IoT); cloud; gamification; mobile/cloud computing; and 3D printing. PCF provides a grant of up to 50% of the approved total project cost, or up to a ceiling of RM750,000 per project, whichever is lower. As a performance-based fund, each project is funded for up to either two years (for projects granted in 2011 – 2014) or one and a half years (for projects granted in 2015). The projects are required to produce at least one IP.

A total of 32 projects amounting to RM20.93 million were funded during 2013 – 2015 (Figure 6.26). The number and amount of approved projects reached 14 and RM8.82 million respectively in 2015. The number and amount of approved projects for PCF was always in an upward trend, and a total of 29 IPs were successfully filed during the three-year period.

Figure 6.26 Number and Amount of Projects Approved, PCF, 2013 – 2015



Source : Malaysia Digital Economy Corporation

6.4 Public Sector Research Programmes

In addition to public R&D grants, the Malaysian government has designed and implemented sectoral specific research programmes that aim to accelerate the development of STI capabilities of several strategic and emerging sectors in the country. These include – among others – biotechnology, nanotechnology, oceanography and Sea to Space (S2S).

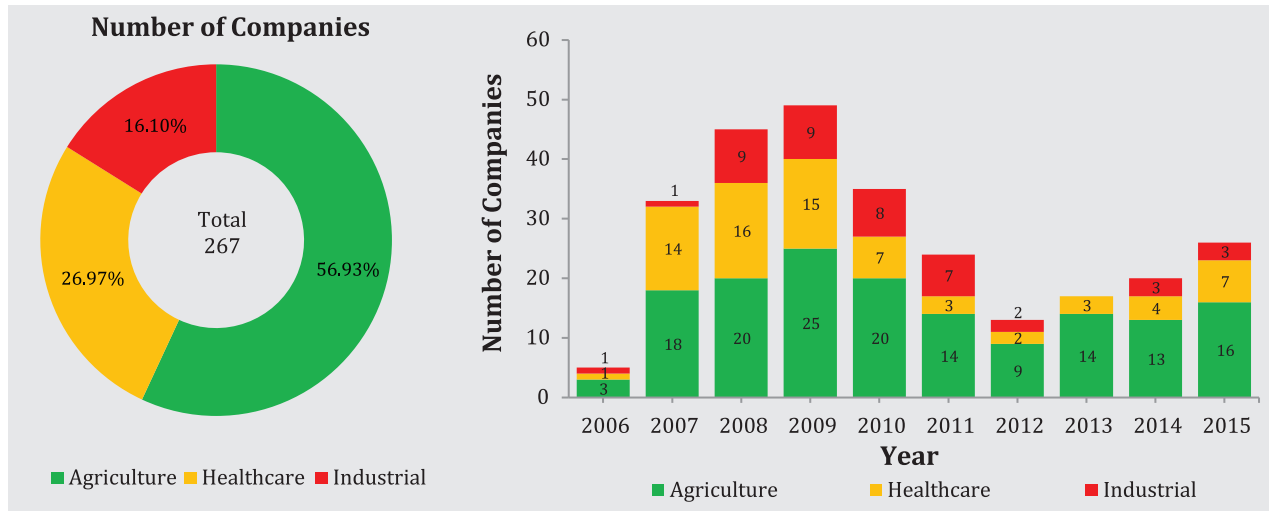
6.4.1 Biotechnology

a) BioNexus Status Companies

The National Biotechnology Policy (NBP) was launched in 2005, with the aim of turning Malaysia's biotechnology sector into one of the key economic drivers of the nation by 2020. The NBP is designed as three five-year phases, namely Capacity Building (2005 – 2010), Science to Business (2011 – 2015), and Global Presence (2015 – 2020). Phase II of the NBP, i.e. Science to Business was implemented during the 10th Malaysia Plan. This phase focuses on the development of expertise in drug discovery and development based on: biodiversity and natural resources; new product development; technology acquisition; promoting foreign direct investment participation; intensifying spin-off companies; strengthening local and global brands; developing capability in technology licensing; and job creation. At the same time, the Bioeconomy Transformation Programme (BTP) was introduced in 2012 to further accelerate the country's Bioeconomy development. BioNexus Status is a recognition awarded by the Government through Malaysian Biotechnology Corporation Sdn. Bhd. (BiotechCorp) to qualified companies that participate in and undertake value-added biotechnology activities.

A total of 57% or 152 approved companies were in the agriculture sector, followed by healthcare sector with 27% or 72 companies, and industrial sector with 16% or 43 companies (Figure 6.27). The number of new approved companies reached a historical high of 49 companies in 2009. This was followed by a sharp drop of 73.47% from the year 2009 till 2012. Nonetheless, the number of approved BioNexus Status companies rebounded slowly, from 13 companies in 2012 to 26 companies in 2015.

Figure 6.27 Number of New Approved BioNexus Companies, 2006 – 2015

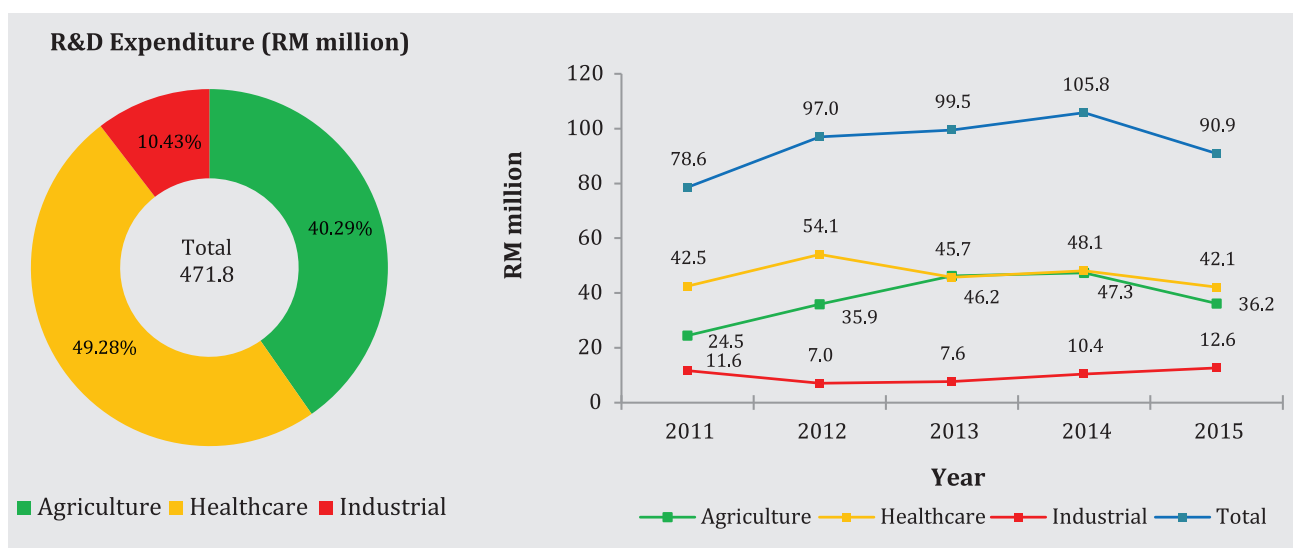


Source : BiotechCorp Malaysia

b) R&D Expenditure

A total of RM471.8 million was spent on R&D related activities by the BioNexus Status companies in the period of 2011 – 2015 (Figure 6.28). About half of the total R&D expenditure was contributed by companies in the healthcare sector with RM232.5 million (49%), followed by agriculture sector and industrial sector with RM190.1 million (40%) and RM49.2 million (11%) respectively. Overall, the total R&D expenditure recorded a decline in 2015 after experiencing three years of consecutive growth from 2011 – 2014. Only companies in the industrial sector experienced a constant growth during the entire period of 2012 – 2015.

Figure 6.28 R&D Expenditure by BioNexus Companies, 2011 – 2015

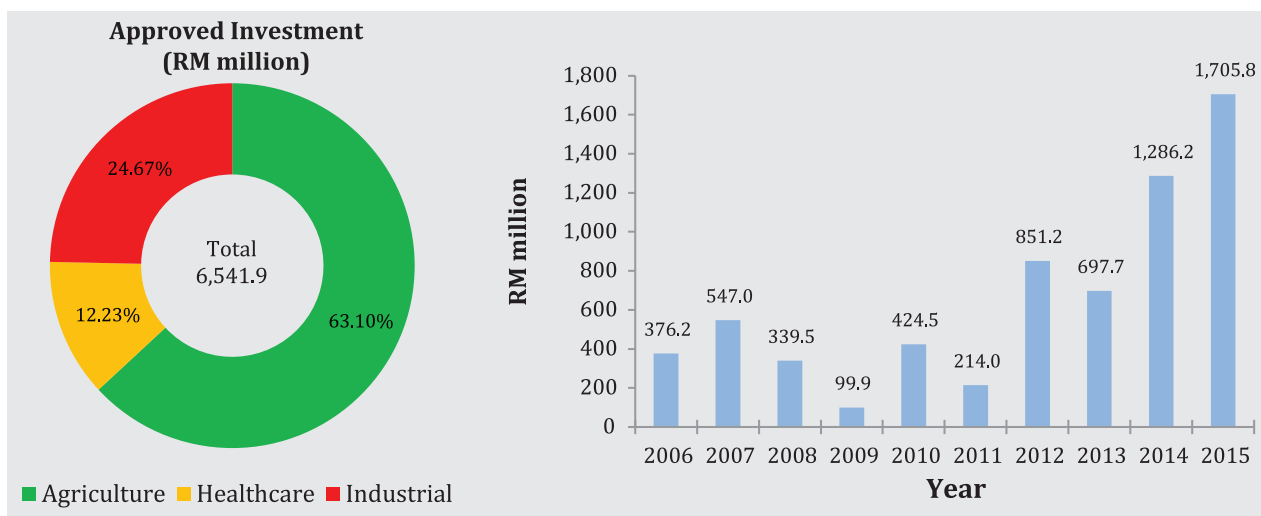


Source : BiotechCorp Malaysia

c) Approved Investment and Realised Investment

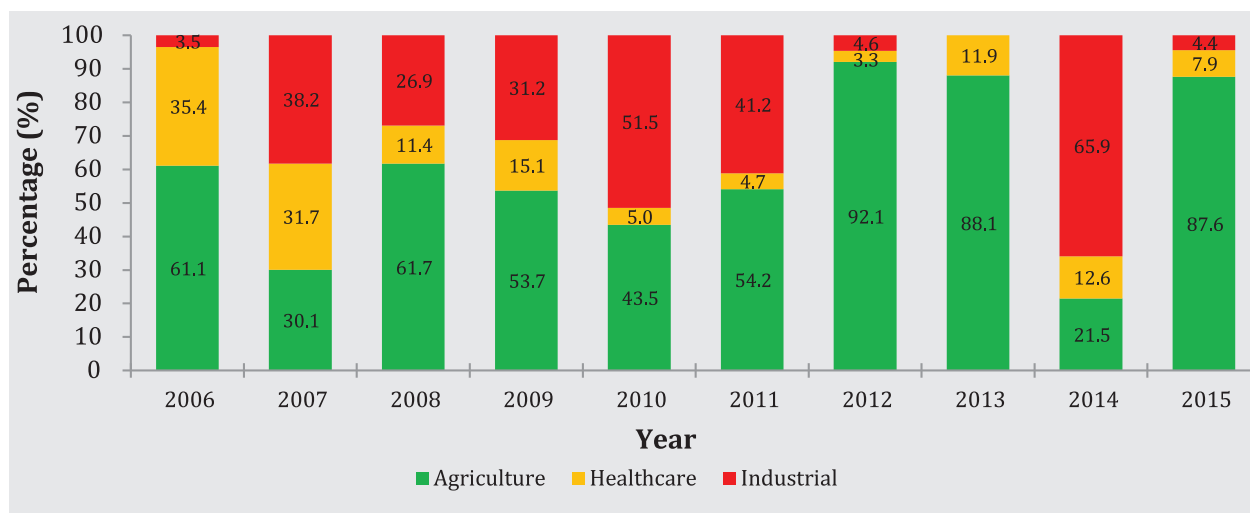
Nearly RM6.54 billion of investment was approved during 2006 – 2015. In general, approved investment during the 10th Malaysia Plan (RM4.75 billion) was far greater compared to the 9th Malaysia Plan (RM1.79 billion) (Figure 6.29). There was exponential growth from RM697.7 million in 2013 to RM1,705.8 million in 2015. Overall, BioNexus companies in the agriculture sector dominated the investment activities during 2006 – 2015 with RM4,127.86 million (63.10%), followed by industrial sector with RM1,613.9 million (24.67%) and healthcare sector with RM800.21 million (12.23%). It is important to note that there was a significant amount of investment by the agriculture sector in 2012, 2013 and 2015, while the industrial sector was leading in 2014 (Figure 6.30).

Figure 6.29 Approved Investment of BioNexus Companies, 2006 – 2015



Source : BiotechCorp Malaysia

Figure 6.30 Approved Investment of BioNexus Companies by Sector, 2006 – 2015

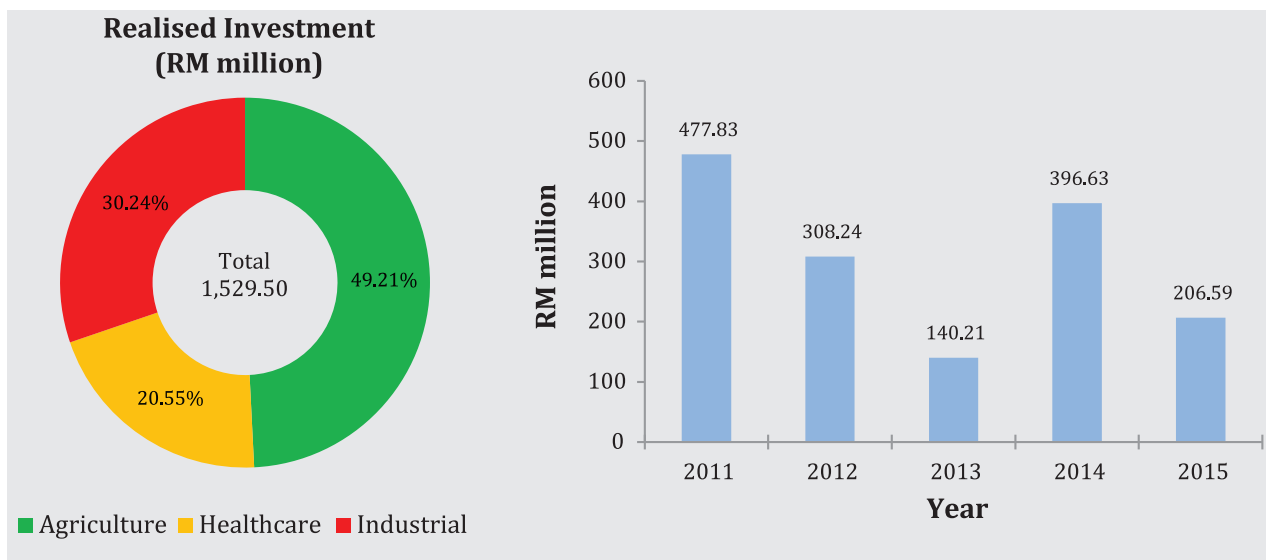


Source : BiotechCorp Malaysia

Figure 6.31 indicates the cumulative realised investment amounting to RM1,529.50 million by BioNexus Companies in the period of 2011 – 2015. Agriculture sector comprised almost half of the amount with RM752.72 million (49.2%). This was followed by industrial sector with RM462.49 million (30.24%) and healthcare sector with RM314.30 million (20.55%). The annual amount of realised investment fluctuated since 2011. The highest amount of realised investment was recorded in 2011 with RM477.83 million. In 2015, the amount accounted for was RM206.59, which is the second lowest since 2011.

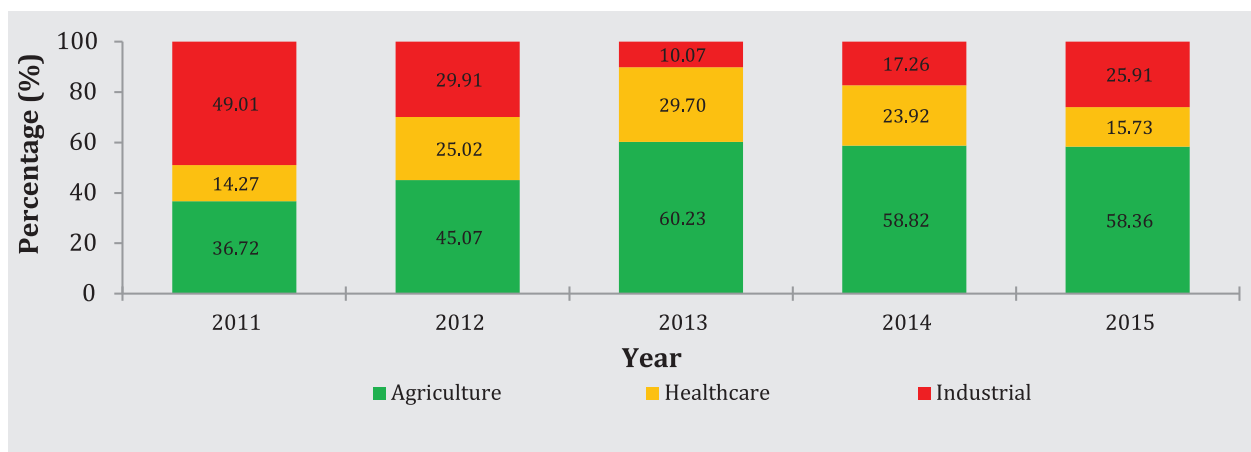
Figure 6.32 presents the performance of each sector’s realised investment. Since taking over the leading position from the industrial sector in 2012, the agriculture sector was the biggest contributor to the realised investment till 2015.

Figure 6.31 Realised Investment of BioNexus Companies, 2011 – 2015



Source : BiotechCorp Malaysia

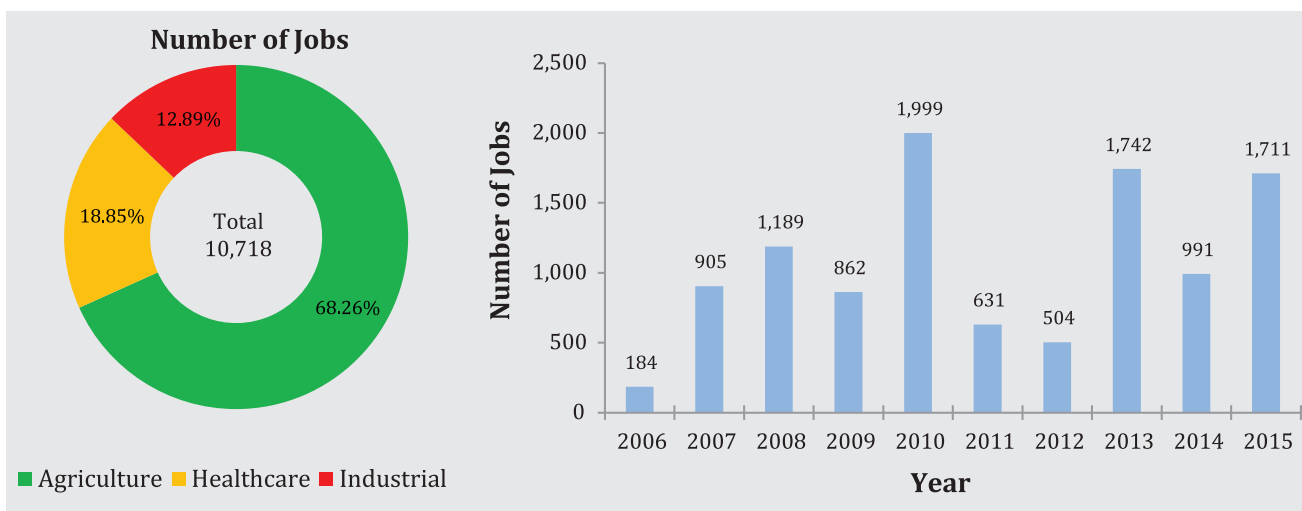
Figure 6.32 Realised Investment of BioNexus Companies by Sector, 2011 – 2015



Source : BiotechCorp Malaysia

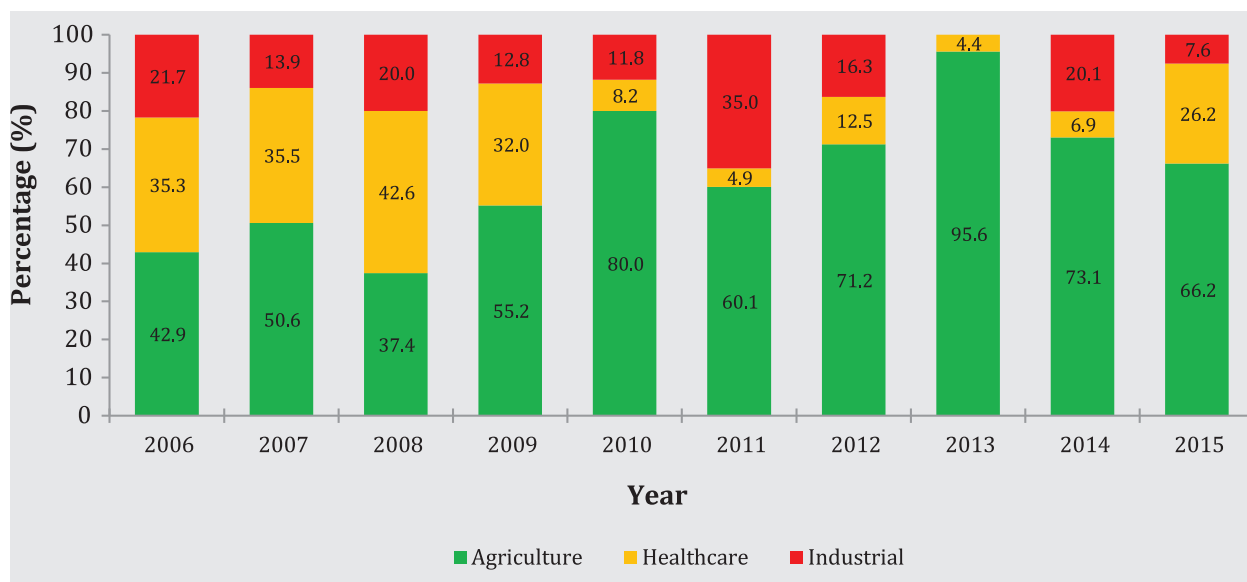
BioNexus companies have created 10,718 job opportunities over the past ten years. More than half (68%) of the job opportunities were created by companies in the agriculture sector. This was followed by healthcare and industrial sectors at 2,020 (19%) and 1,382 (13%), respectively (Figure 6.33). The highest job creation was in 2010 with 1,999 new jobs. Job creation was also relatively high in 2013 and 2015 with 1,742 and 1,711 new jobs respectively (Figure 6.33). BioNexus Status companies are expected to contribute to the national knowledge-based economy agenda. In 2006 – 2005, a total of 1,809 (48%) knowledge workers were employed in the agriculture sector, while healthcare sector employed 1,381 persons (37%) and industrial sector employed 545 persons (15%) (Figure 6.35). Annually, the highest employment was in 2007 and 2008. Except for 2006, 2008 and 2015, the agriculture sector was always the sector employing the most knowledge workers (Figure 6.36).

Figure 6.33 Jobs Created by BioNexus Companies, 2006 – 2015



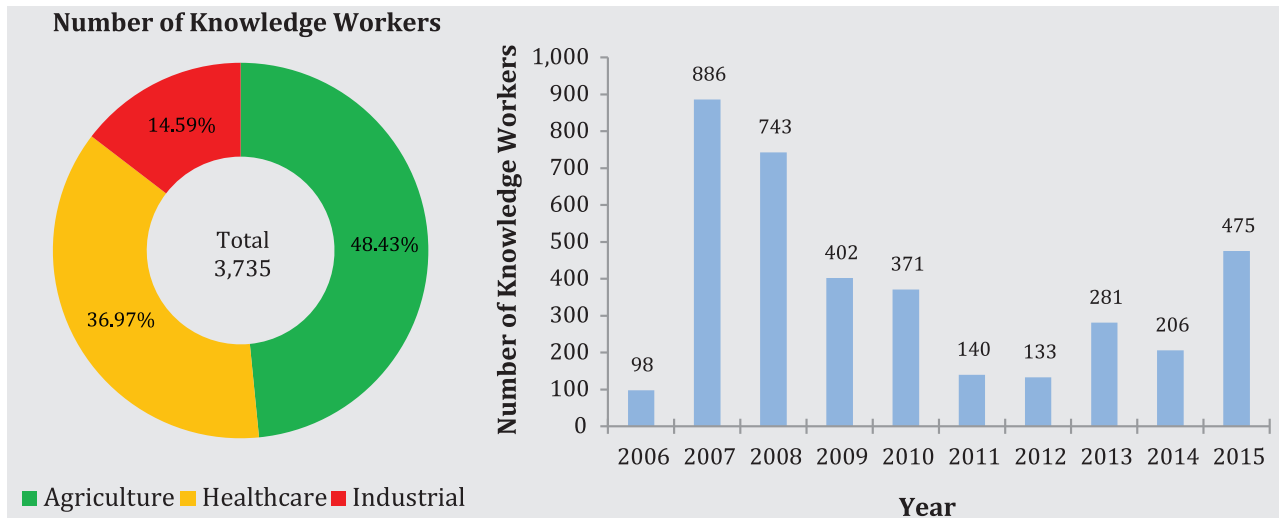
Source : BiotechCorp Malaysia

Figure 6.34 Jobs Created by BioNexus Companies by Sector, 2011 – 2015



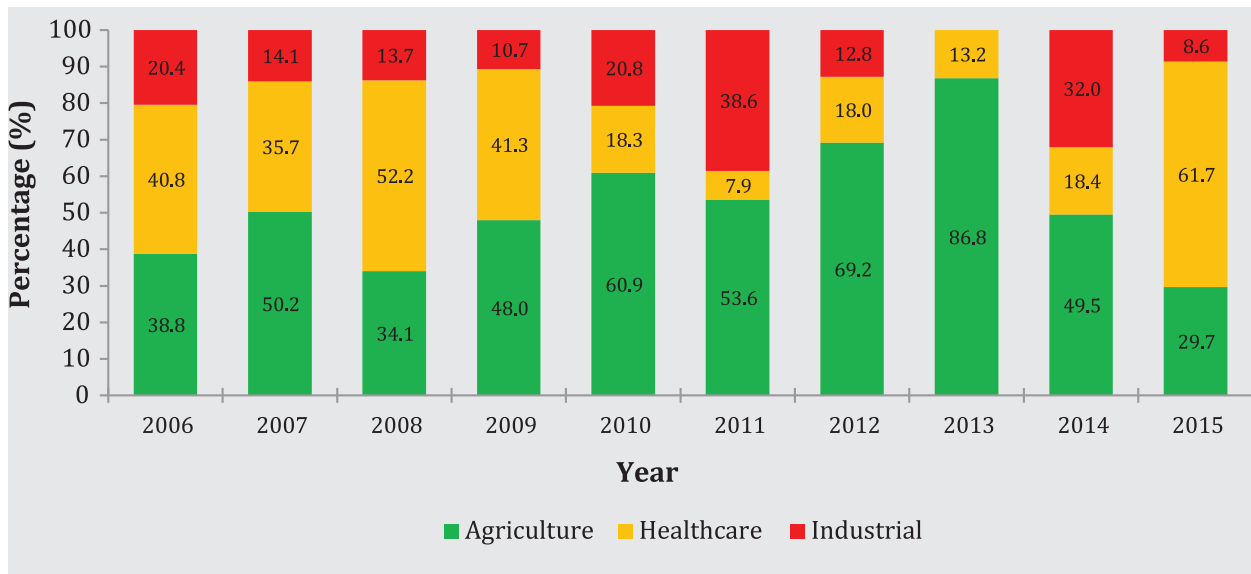
Source : BiotechCorp Malaysia

Figure 6.35 Knowledge Workers Employed, BioNexus Companies, 2006 – 2015



Source : BiotechCorp Malaysia

Figure 6.36 Knowledge Workers Employed, BioNexus Companies by Sector, 2006 – 2015



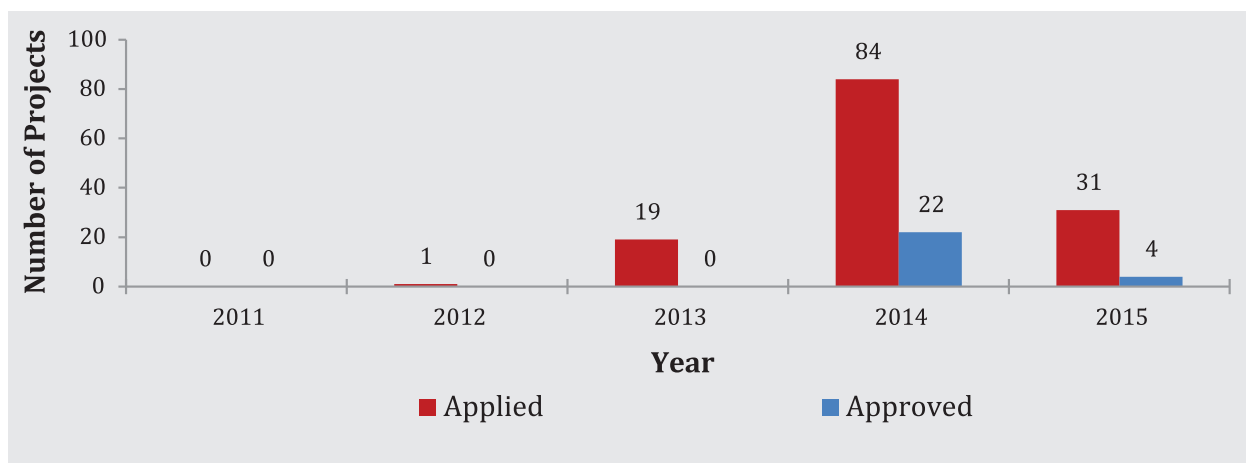
Source : BiotechCorp Malaysia

6.4.2 Nanotechnology

The National Nanotechnology Directorate (NND) was established on 13th January 2010 and officially began operations in July 2010 under the auspices of MOSTI. NND serves as the National Focal Point for the coordination of research, development and all related activities of nanotechnology in Malaysia. NND is also tasked to create awareness by creating a conducive environment that encourages invention, innovation and technology development in the nanotechnology community. In 2011 – 2015, there were 135 ScienceFund project applications with total value of RM37.55 million related to nanotechnology research (Figure 6.37). Out of these numbers, a total of 26 ScienceFund projects valued at RM5.73 million

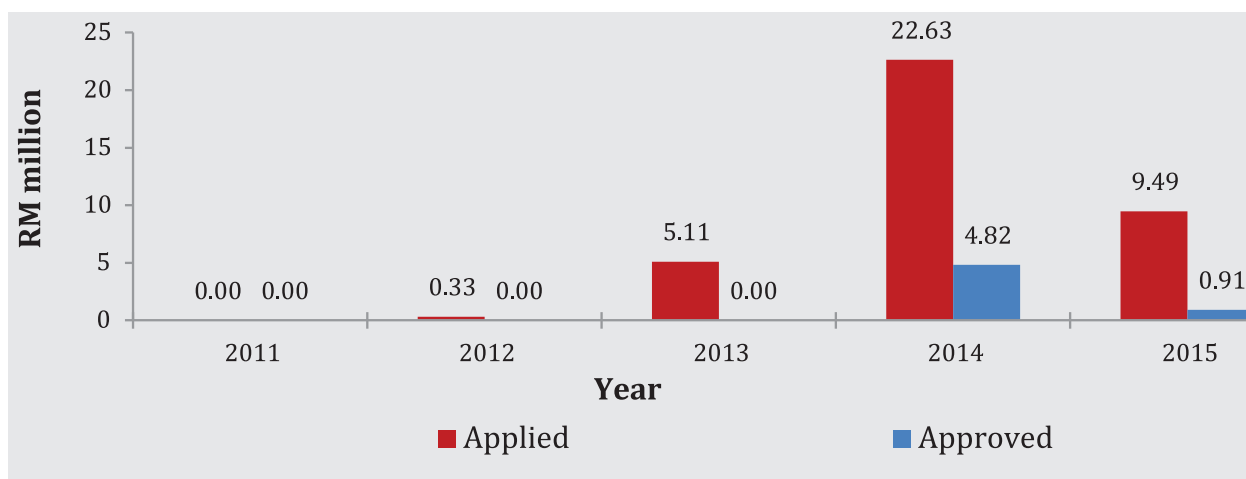
were granted by MOSTI (Figure 6.38). The highest number and amount of applications and approvals were recorded in the year 2014.

Figure 6.37 Number of Applications and Approvals, Nanotechnology, ScienceFund, 2011 - 2015



Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.38 Amount of Applications and Approvals, Nanotechnology, ScienceFund, 2011 - 2015



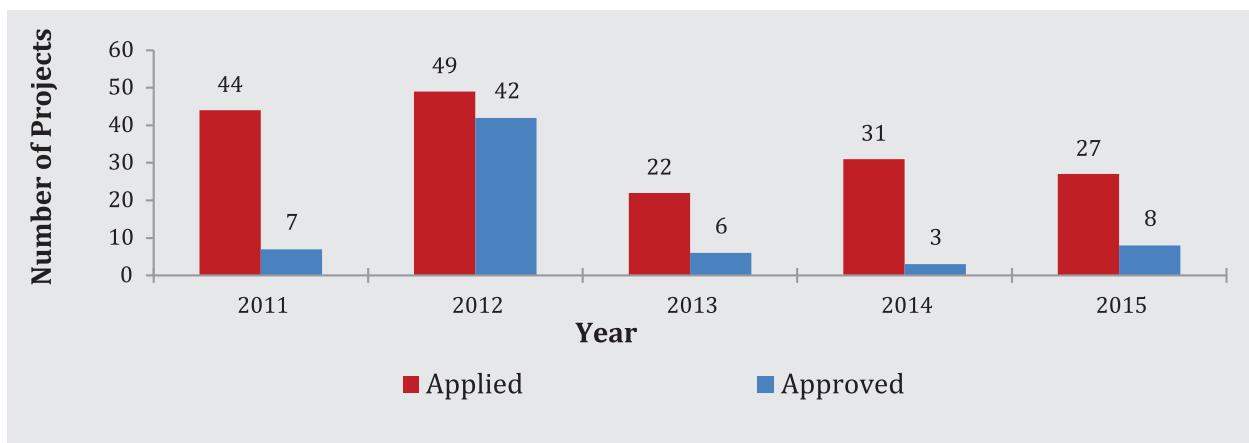
Source : Ministry of Science, Technology and Innovation Malaysia

6.4.3 Oceanography

The National Oceanography Directorate (NOD) was established on 1st November 2000 to serve as the national focal point for the coordination of all R&D and commercialisation activities related to oceanography and marine science in Malaysia. The key research priority areas of NOD are: marine expedition and data management; marine biotechnology or bioprospecting; meteorological oceanography or natural hazards and pollution; land-sea interaction and processes; marine renewable energy; and marine solutions and instrumentation. During the

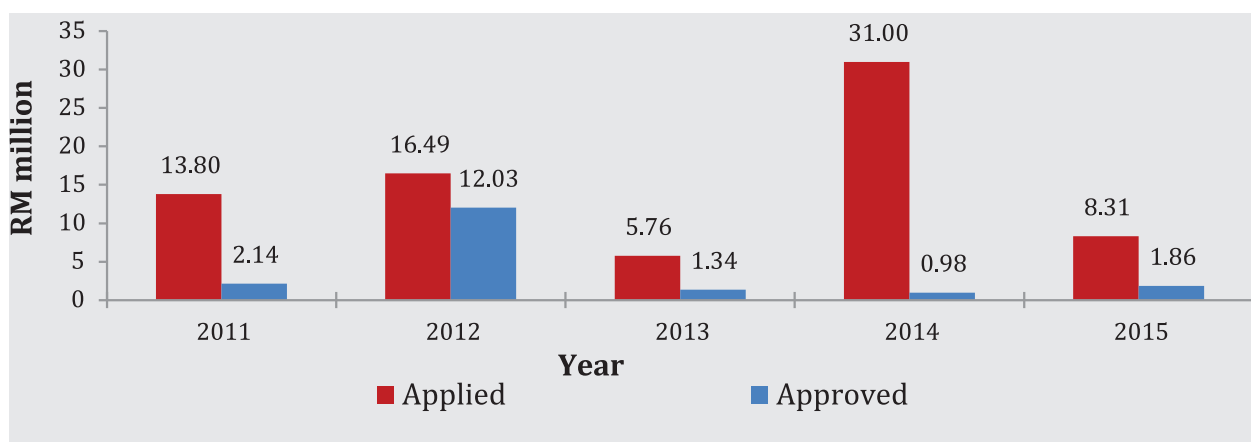
9th Malaysia Plan, NOD only received RM12.25 million from ScienceFund¹⁹. Nonetheless, the allocation of ScienceFund increased markedly in the 10th Malaysia Plan. Figure 6.39 shows the number of applications and approvals of oceanography related projects under ScienceFund during the period of 2011 – 2015. A total of 173 applications were submitted, of which 66 or 38.15% were granted. The amount of applications and approvals is shown in Figure 6.40. A total of RM75.36 million was applied, and 24.35% of this amount or RM18.35 million was approved by MOSTI. The highest number and amount of projects recorded was in 2012. Besides, the Malaysian (Oceanographic) Data Aggregation and Archive System (MyDAS), a flagship project valued RM3.8 million, was initiated in 2013. At the regional level, Malaysia has been actively involved in the Coral Triangle Initiative (CTI) (Box 6.1).

Figure 6.39 Number of Applications and Approvals, Oceanography, ScienceFund, 2011 – 2015



Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.40 Amount of Applications and Approvals, Oceanography, ScienceFund, 2011 – 2015



Source : Ministry of Science, Technology and Innovation Malaysia

¹⁹ Laporan Akhir: Kajian Strategik bagi Penubuhan Institut Oseanografi Negara, Direktorat Oseanografi Kebangsaan, Kementerian Sains, Teknologi dan Inovasi Malaysia.

Box 6.1: Coral Triangle Initiative

The Coral Triangle Initiative (CTI) is a multilateral collaboration to safeguard the region's marine and coastal biological resources. The boundary of the Coral Triangle region encompass the Exclusive Economic Zones (EEZ) of the six countries, namely Indonesia, Malaysia, Papua New Guinea, the Philippines, the Solomon Islands, and Timor-Leste. Listed in Table 6.2 are the community projects on CTI funded by the Malaysian Government during the 10th Malaysia Plan. The total amount of these projects was RM989,960.

Table 6.2 Community Projects on Coral Triangle Initiative under 10th Malaysia Plan

No.	Project Title	RM
1	Assessing coastal adaptation to climate change in CTI	70,000
2	Development of environmental education module and board games on marine environment for communities in Sabah	310,000
3	Demonstration of best practices in fisheries management within the context of the Ecosystem Approach to Fisheries Management (EAFM)	350,000
4	A study of IUU on tuna fisheries in Semporna	60,000
5	Address problems faced by seaweed farmers	79,960
6	Mapping of coral trout spawning aggregation at Lankayan Island	60,000
7	Value chain of tuna in Semporna	60,000

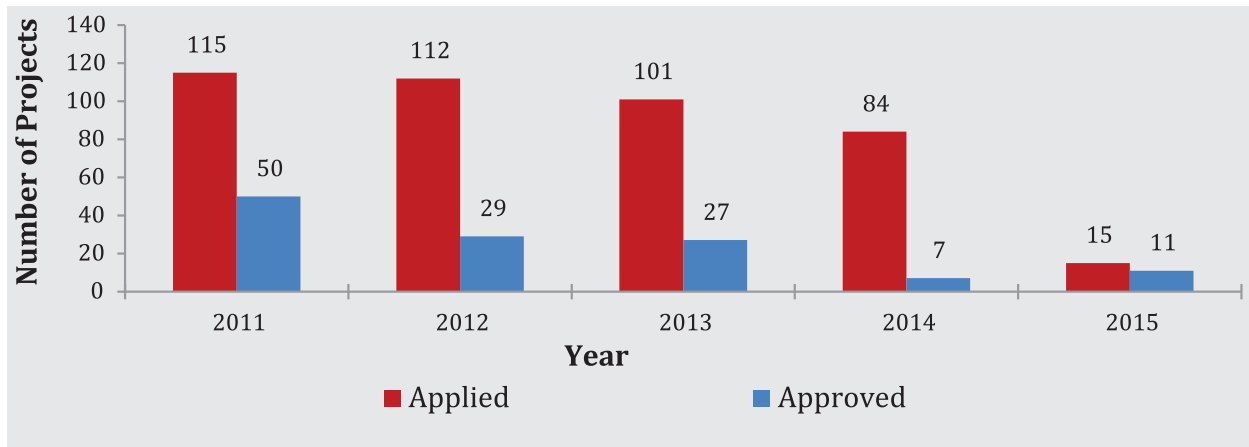
Source : National Oceanography Directorate Malaysia

6.4.4 Sea to Space

The Sea to Space (S2S) Division of MOSTI is responsible for planning, spearheading and coordinating the policy direction of S2S Cluster involving three government agencies – namely the National Space Agency (ANGKASA), Malaysian Remote Sensing Agency (ARSM) and Malaysian Meteorological Department (MMD) – and also Astronautic Technology (M) Sdn. Bhd. (ATSB®) which is a government linked company. ANGKASA's role is to harness space as a platform for knowledge generation, wealth creation and societal well-being. The Malaysia Remote Sensing Agency is a centre of excellence in advancing new applications of remote sensing and related technologies. MMD's mission is to fulfil the needs of society through meteorological, climatological and geophysical services for societal well-being, national security and sustainable socio-economic development. Meanwhile, ATSB® develops advanced space systems and related technologies that will provide value-added applications for global customers.

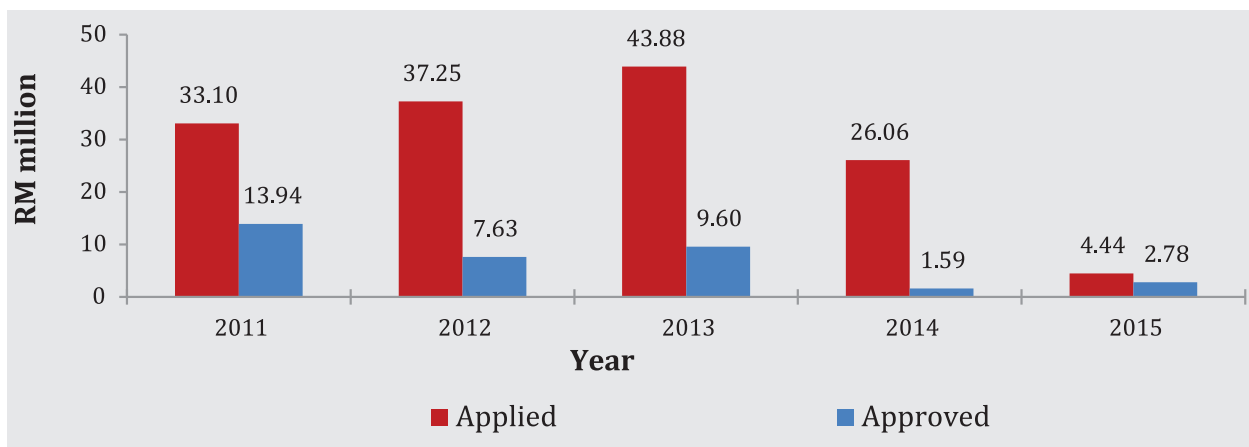
Figure 6.41 shows the number of applications and approvals of S2S related projects under ScienceFund during the period of 2011 – 2015. A total of 427 applications were made, of which 124 or 29.04% were granted. Figure 6.42 shows the amount of applications and approvals. A total of RM144.73 million was applied, and RM35.52 million or 24.54% was approved by MOSTI.

Figure 6.41 Number of Applications and Approvals, S2S, ScienceFund, 2011 – 2015



Source : Ministry of Science, Technology and Innovation Malaysia

Figure 6.42 Amount of Applications and Approvals, S2S, ScienceFund, 2011 – 2015



Source : Ministry of Science, Technology and Innovation Malaysia

Other specific projects under S2S cluster includes the Enhancement of Prototype Synthetic Aperture Radar-Unmanned Aerial Vehicle (SAR-UAV) System as illustrated in Box 6.2.

Box 6.2: Enhancement of Prototype Synthetic Aperture Radar-Unmanned Aerial Vehicle (SAR-UAV) System

The project entitled “Enhancement of Prototype Synthetic Aperture Radar-Unmanned Aerial Vehicle (SAR-UAV) system for multipurpose remote sensing application” valued at RM300 million was launched in 2006. The collaboration between the Ministry of Defence (MINDEF) and Unmanned Systems Technology Sdn. Bhd. was instrumental in developing a prototype of an airborne remote sensing synthetic aperture radar system, which operates as an Unmanned Aerial Vehicle (UAV). The project aims to increase UAV flying range, develop capability for night flying, develop capability for wet weather flying, enhance SAR sensors, as well as integrate an optical sensor.

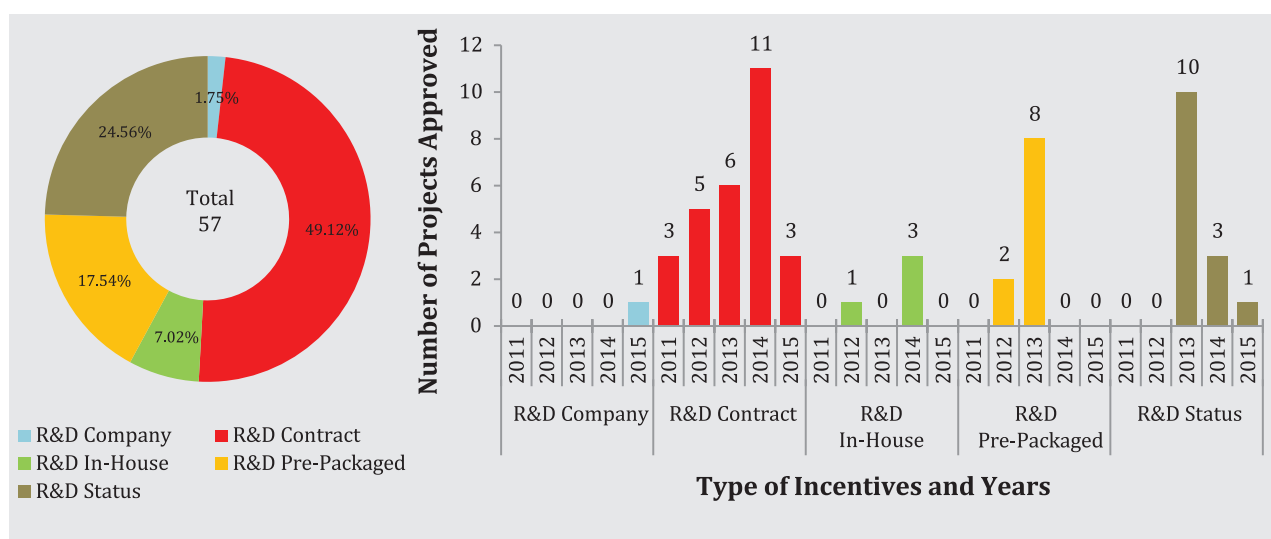
6.5 R&D Investment Incentives

Under the Promotion of Investments Act 1986, various tax incentives were made available by the Government under MIDA to promote industry participation in undertaking R&D related activities. Under this act, eligible companies will be given pioneer status with income tax exemption, Investment Tax Allowance (ITA), and infrastructure allowance. The following entities are eligible to apply for the tax incentives:

- *Contract R&D Company* – A company that provides R&D services in Malaysia to unrelated companies.
- *R&D Company* – A company that provides R&D services in Malaysia to its related company or unrelated companies.
- *In-House R&D* – A company carries out R&D within the company in Malaysia for its own business.
- *Pre-Packaged R&D* – A negotiable customised incentive based on request of the company and the merit of each R&D intensive project.
- *R&D Status Company* – A R&D company that enables its collaborators (Malaysian companies) to benefit from a tax deduction when they invest in R&D.

A total of 57 R&D projects under the various categories of incentives were approved by MIDA during 2011 – 2015 (Figure 6.43). Over the period, Contract R&D Company dominated with almost half of the approvals with 28 projects (49%) out of the total approved projects. This is followed by R&D Status Company with 14 projects approved (25%), and Pre-Packaged R&D with 10 approvals (17%). The number of approvals in the category of R&D In-House and R&D Company were relatively few, with just 4 projects (7%) and 1 project (2%) respectively. Meanwhile, since 2013 the total number of approvals has been declining. The number has reduced sharply, from 24 projects in 2013 to 17 projects in 2014, and only five projects in 2015.

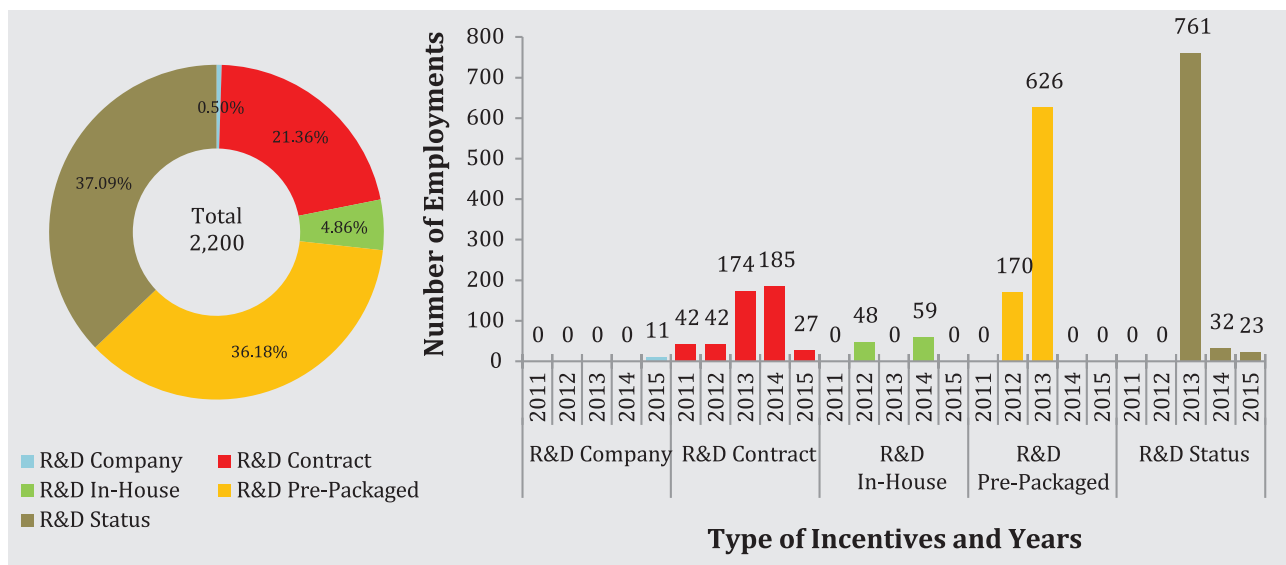
Figure 6.43 Number of R&D Projects Approved by Type of MIDA's Incentives, 2011 – 2015



Source : Malaysian Investment Development Authority

Overall, the approved projects have created 2,200 employments (Figure 6.44). R&D Status Company was the main contributor that employed 816 or 37% of the total employment. This is followed by R&D Pre-Packaged with 796 employments (36%) and R&D Contract with 470 employments (21%). R&D In-House and R&D Company contributions were relatively small with just 107 employments (5%) and 11 employments (1%) respectively over the past five years. The number of employments has been declining, from 1,561 to only 61 over just two years.

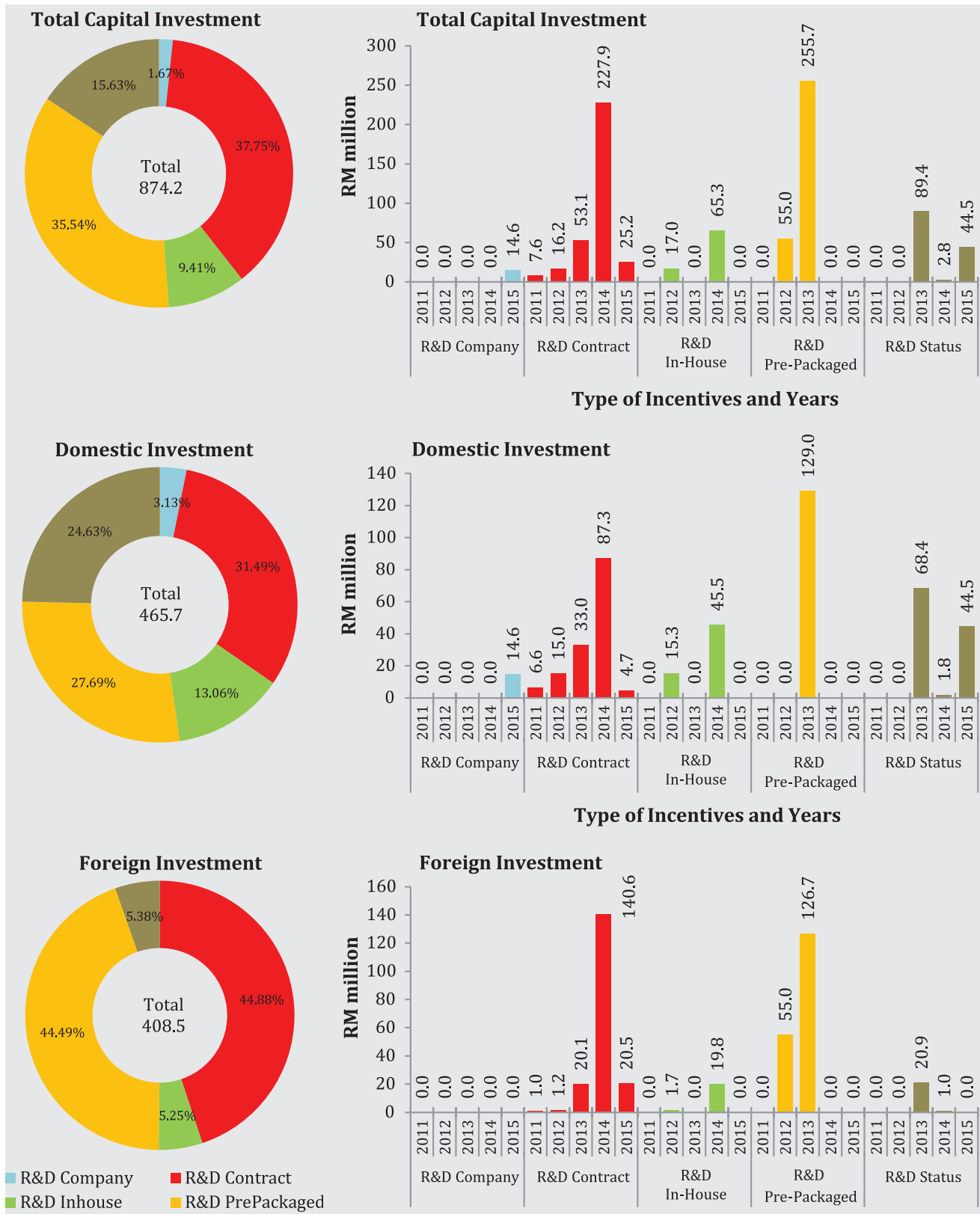
Figure 6.44 Number of Employments by Type of MIDA's Incentives, 2011 - 2015



Source : Malaysian Investment Development Authority

A total of RM874.2 million in capital investments was recorded during 2011 - 2015 (Figure 6.45). Out of the total capital investment, RM465.7 million (53.27%) was from domestic investors while the remaining RM408.5 million (46.73%) was from foreign investors. The investments are highly concentrated in R&D Contract and R&D Pre-Packaged projects that contributed RM330.0 million (38%) and RM310.7 million (35%) respectively. R&D Status Companies were the third largest contributor with RM136.7 million (16%), while R&D In-House and R&D Companies contributed the least to the overall capital investments, with RM82.3 million (9%) and RM14.6 million (2%) respectively.

Figure 6.45 Capital Investments by Type of MIDA's Incentives, 2011 - 2015

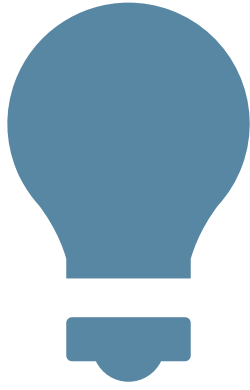


Source : Malaysian Investment Development Authority

6.6 Summary

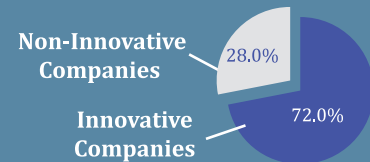
Malaysia's public funding schemes encompass the full spectrum of R&D and commercialisation stages, i.e. pre-R&D, research, development and commercialisation. At the pre-R&D stage, Cradle approved 134 CIP Catalyst projects (RM44.88 million), 7 U-CIP Catalyst projects (RM1.05 million) and 147 CIP 500 projects (RM72.19 million) in 2011 – 2015. At the R&D stage, 1,489 applications valued at RM309.27 million were approved under ScienceFund during 2011 – 2015. Besides, a total of 6,874 FRGS projects valued at RM631.80 million have been disbursed by MOHE to the respective researchers. Other grants supported by MOHE includes ERGS, RAGS, PRGS, RACE and LRGS.

In terms of development stage, MOSTI has approved 113 projects valued at RM212.05 million under TechnoFund during 2011 – 2015. At the same time, 83 InnoFund projects were granted with a total allocation of RM23.21 million. MOSTI granted 113 projects valued at RM212.05 million under TechnoFund. More than half the approved TechnoFund projects were in the Industry cluster. For InnoFund, 83 projects were granted with a total allocation of RM23.21 million. Like the case for TechnoFund, most approved projects were from the Industrial cluster. PCF, MAC3 and BCi2 were three funds under the administration of MDEC to support ICT industry development, while BCF was targeting at funding commercialisation activities. Under the purview of BiotechCorp, a total of 25 BCF projects were approved with a total amount of RM71.7 million. On the other hand, MDEC gave out a total of 32 PCF projects amounting to RM20.93 million in 2013-2015. The Government also initiated public research programmes in the fields of biotechnology, nanotechnology, oceanography and S2S during the 10th Malaysia Plan. Also, under the Promotion of Investments Act 1986, various tax incentives were made available by the Government under MIDA to promote industry participation in undertaking R&D related activities.



Innovation in Manufacturing and Services Sectors

TOTAL COMPANIES: 1,685
(Manufacturing and Services Sectors)



- Manufacturing sector: 68.87% are Innovative Companies (469 companies)
- Services sector: 74.10% are Innovative Companies (744 companies)

Number of Innovative Companies

Most of the innovative companies are

- Private limited companies
- Small companies
- >RM6million in annual sales
- <=RM25,000 spent during period of innovation activities

Profile of Innovative Companies

Types of Innovation

- **Product** Innovation
- **Process** Innovation
- **Marketing** Innovation
- **Organisational** Innovation

Objectives of Innovation

Main objectives:

- (for both manufacturing and services sectors)
- to improve product quality
 - to fulfill regulations and standards

▶▶ CHAPTER 7

Main effect:

- Improved quality of goods and services



Effects of Innovation

- Manufacturing sector: technical support services (30.70%); government tax incentives (28.78%)
- Services sector: technical consultancy services (20.70%); government R&D grant (10.08%)
- Main source of funding: Own sources
- Market sources of information such as clients or suppliers have the highest degree of importance to obtain information for innovation activities



Resources for Innovation



Factors Hampering Innovation Activities

- **Cost** of innovation is too high
- Lack of **qualified personnel**



International Comparison

Malaysia is among the top 20 most competitive economies globally, ranking 18th in GCI 2015 - 2016

- Malaysia is ranked **35th** in GII 2016, higher than Thailand (52nd) and Indonesia (88th) but lower than Singapore (6th)
- Malaysia is ranked **59th** in terms of innovation efficiency ratio



CHAPTER 7: INNOVATION IN MANUFACTURING AND SERVICES SECTORS

7.1 Introduction

Globally, innovation is regarded as a key driver of economic growth. An innovative economy provides the competitive edge to compete successfully in the international market. Hence, it is important to keep track of the level and status of innovation activities in Malaysia. Through the understanding of the current status of innovation, Malaysia is able to plan and formulate effective policies to create and continuously support an innovative culture for sustainable economic growth. The Malaysian Science and Technology Information Centre (MASTIC) carried out the first National Survey of Innovation (NSI) in 1994, targeting the manufacturing sector in Malaysia in order to gauge the level of innovation activities. Since 1994 six more surveys have been conducted, and in the 2005 – 2008 survey the services sector in Malaysia was included. The latest NSI-2015 covers innovation activities over the period of 2012 – 2014²⁰. This chapter reports the findings of the 2015 survey and compares the innovation activities across manufacturing and services sectors.

7.2 Overview of Innovation in the Malaysian Manufacturing and Services Sectors

The NSI-2015 analysis covers a total of 1,685 companies; 681 are from the manufacturing sector, while 1,004 respondents are from the services sector. The following sections describe the profile of innovative companies in both the manufacturing and services sectors.

7.2.1 Innovative and Non-Innovative Companies

The NSI-2015 survey shows that 72.0% of the companies are innovative companies, while 28.0% are non-innovative companies. By comparison, in 2012 70.0% of the companies were innovative companies, while 30.0% were non-innovative companies (Table 7.1).

Table 7.1 Innovative and Non-Innovative Companies, 2012 and 2015

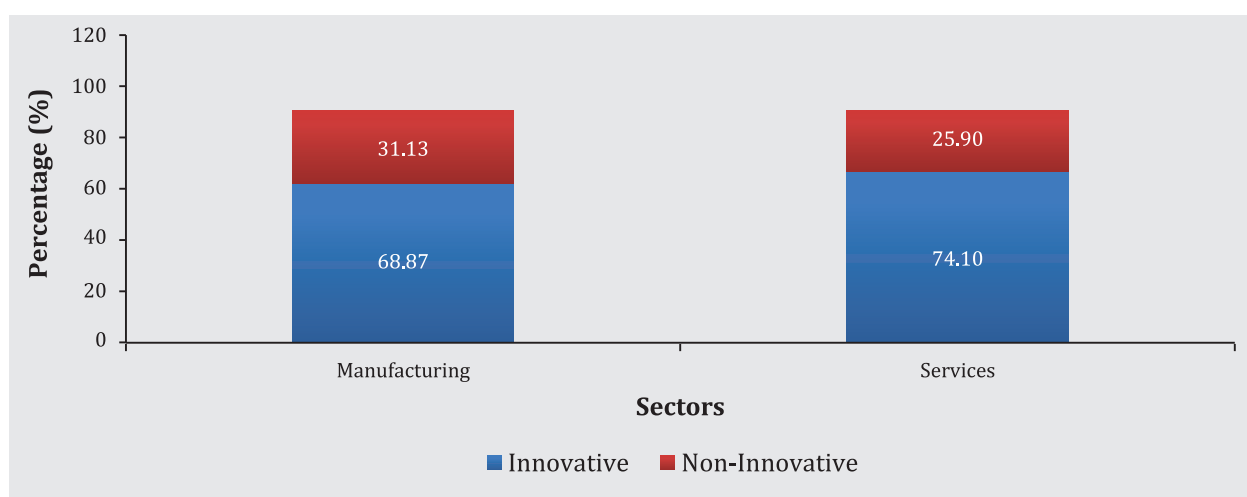
Companies	2012		2015	
	Number of Companies	Percentage (%)	Number of Companies	Percentage (%)
Innovative	1,178	70.0	1,213	72.0
Non-Innovative	504	30.0	472	28.0
Total	1,682	100	1,685	100

Source : National Survey of Innovation 2015

²⁰ Sample for 2015 survey was drawn from 645,632 registered companies in manufacturing and services sectors in 2014 (Department of Statistics Malaysia – January 2014). Definition of key terms in this chapter follows that of NSI-2015.

Among the 1,213 innovative companies, 61.3% (744) are from the services sector, with the remaining 38.7% (469) represented by the manufacturing sector. Out of the 472 non-innovative companies, 55.1% (260) are from the services sector, while the manufacturing sector represents 44.9% (212). About three quarters of the companies in the services sector (74.10%) claim that their companies are innovative companies (Figure 7.1). Slightly more than two thirds of the manufacturing sector (68.87%) indicated that their companies are innovative. It appears that the services sector is more innovative compared to the manufacturing sector.

Figure 7.1 Percentage of Innovative and Non-Innovative Companies by Sectors



Source : National Survey of Innovation 2015

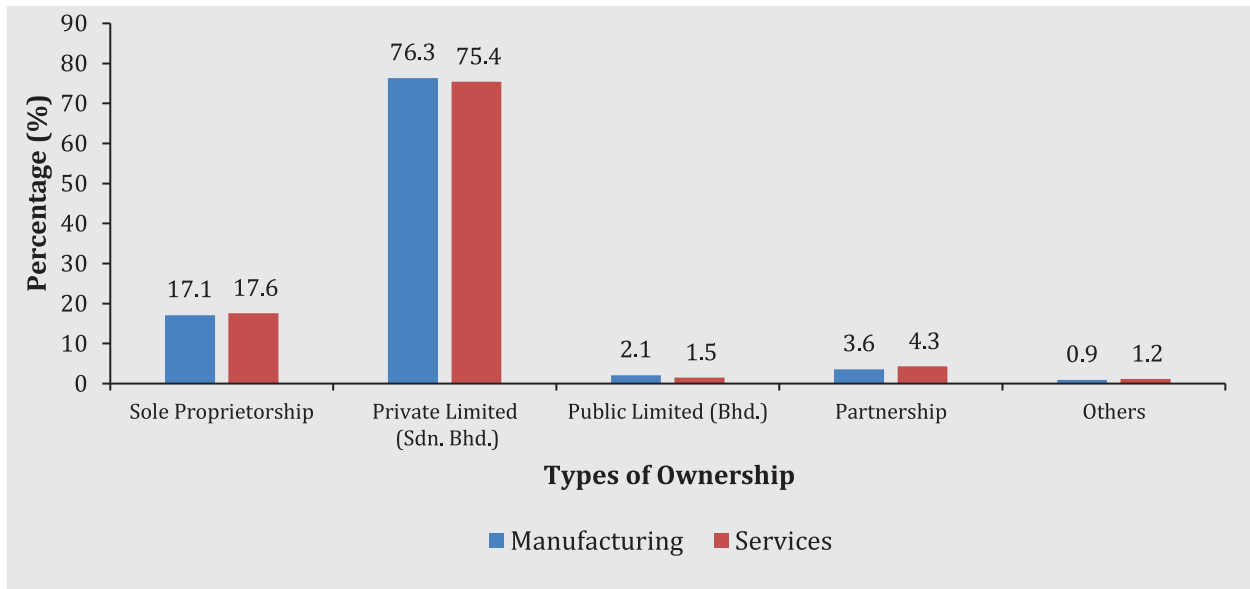
7.2.2 Profile of Innovative Companies

It is of interest to note the characteristics of innovative companies. In terms of ownership of the 469 innovative companies in manufacturing (744 in services), 76.3% (75.4%) are private limited companies, followed by 17.1% (17.6%) under sole proprietorship (Figure 7.2). Below 5% of innovative manufacturing and services companies, respectively, are public limited companies or under partnership.

In terms of size measured based on full-time employees, small-sized companies represent almost 78.0% of the innovative companies in manufacturing sector and 93.4% in services sector respectively (Table 7.2). These percentages are markedly different from those in the previous NSI-2012 survey due to the difference in definition of the size of a company.

A majority of the innovative companies in both the manufacturing (61.0%) and services (60.3%) sectors recorded annual sales of more than RM6,000,000. Nearly 17.1% of the innovative companies in manufacturing and 33.1% in services sectors recorded annual sales from RM5,000,001 to RM6,000,000. In comparison, a higher percentage of the innovative companies in the services sector (93.4%) were able to record more than RM5,000,000 in annual sales compared to the manufacturing sector (78.1%) (Figure 7.3).

Figure 7.2 Types of Ownership of Companies by Sectors



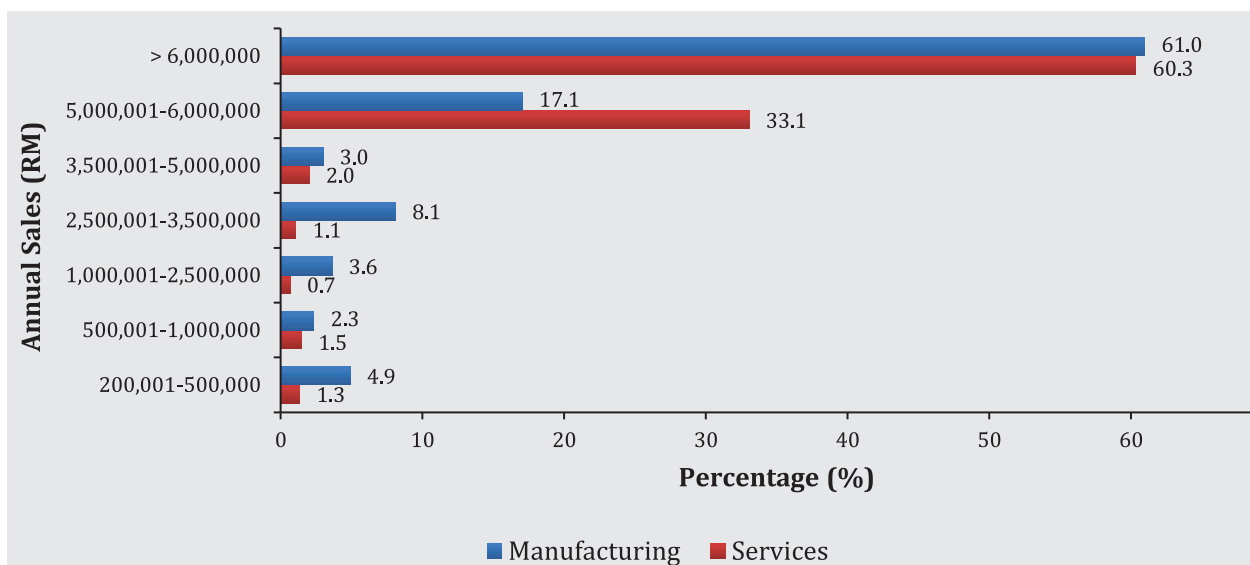
Source : National Survey of Innovation 2015

Table 7.2 Innovative Companies by Company Size, 2012 and 2015

Size of Company	2012		2015	
	Manufacturing (%)	Services (%)	Manufacturing (%)	Services (%)
Small	25.0	46.0	78.0	93.4
Medium	33.0	37.0	14.7	3.8
Large	42.0	17.0	7.3	2.8
Total	100	100	100	100

Source : National Survey of Innovation 2015

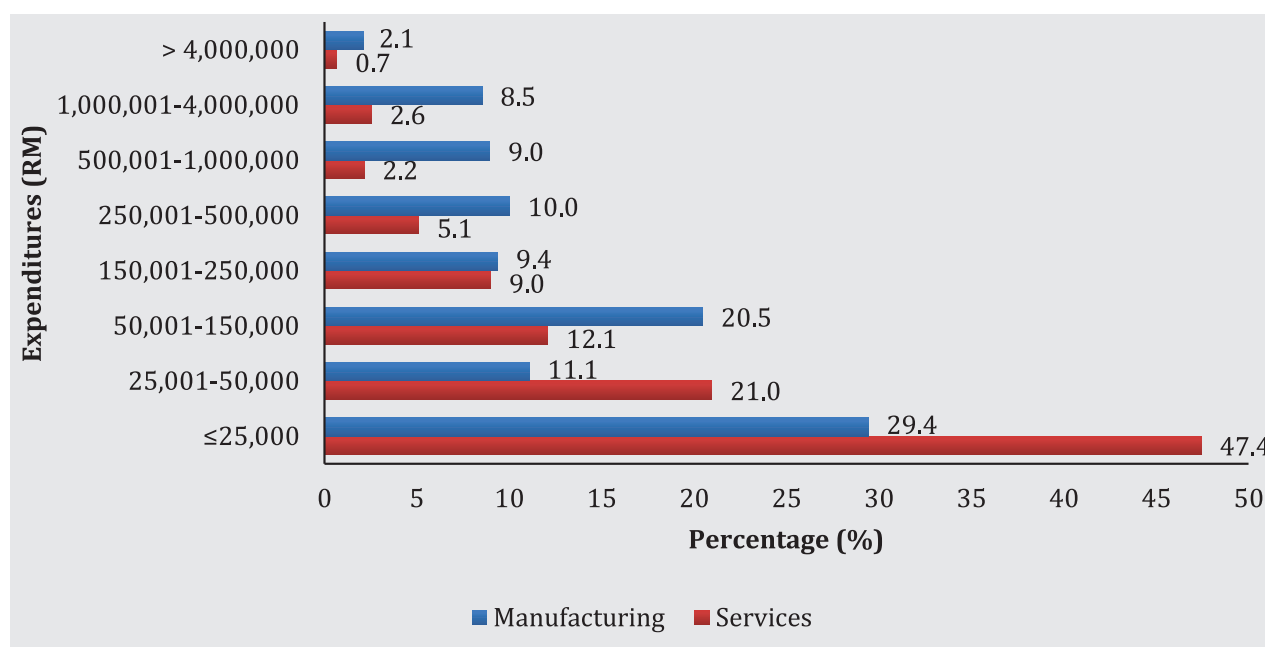
Figure 7.3 Innovative Companies by Annual Sales



Source : National Survey of Innovation 2015

NSI-2015 defines expenditures as the money spent during the period of innovation activities being performed. As high as 47.4% of the innovative companies in the services sector spent equal to or less than RM25,000. In contrast, 29.4% of the innovative manufacturing companies spent equal to or less than RM25,000. On the other hand, only 2.1% and 0.7% in the manufacturing and services sectors respectively spent more than RM4,000,000 for innovation activities (Figure 7.4). Probably due to the nature of innovation activities, the innovative companies in the services sector generally have lower expenditures compared to the manufacturing sector.

Figure 7.4 Innovative Companies by Expenditures



Source : National Survey of Innovation 2015

7.3 Innovation Activities in the Manufacturing and Services Sectors

The NSI-2015 surveyed four types of innovation activities, namely: product; process; marketing; and organisational innovations. The nature of the innovative activities is further discussed in the following sections.

7.3.1 Product Innovation

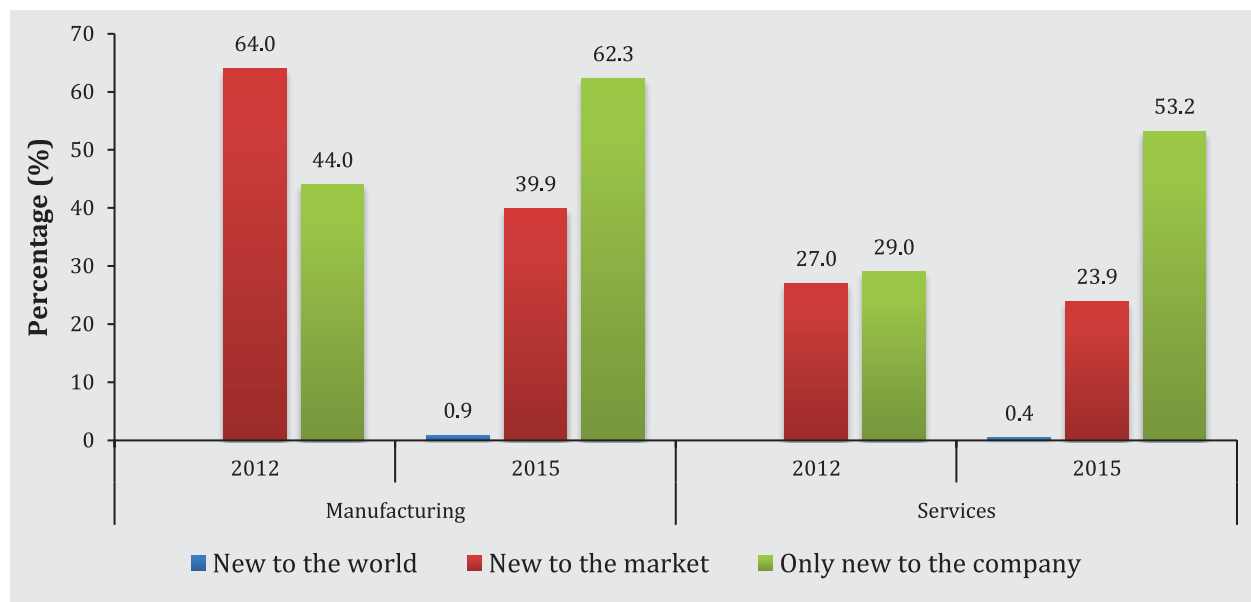
Product innovation refers to “the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses”. Due to the sectoral nature, in the manufacturing sector a majority of product innovation comprises new or significantly improved products (66.3% of the 469 companies), while in the services sector this comprises new or significantly improved services (53.0% of 744 companies). The innovation can be classified as new to the world, new to the market, and new to the company (Table 7.3). Most of the product innovation is only new to the company for both the manufacturing and services sectors. Less than 1% of the respondents in either sector indicated having product innovation that is new to the world.

Table 7.3 Novelty of Product Innovation by Sectors

Novelty of Product Innovation	Manufacturing			Services		
	Yes	No	Total	Yes	No	Total
New to the world	4 (0.9%)	465 (99.1%)	469 (100%)	3 (0.4%)	741 (99.6%)	744 (100%)
New to the market	187 (39.9%)	282 (60.1%)	469 (100%)	178 (23.9%)	566 (76.1%)	744 (100%)
Only new to the company	292 (62.3%)	177 (37.7%)	469 (100%)	396 (53.2%)	348 (46.8%)	744 (100%)

Source : National Survey of Innovation 2015

Between 2012 and 2015 there is an obvious increase in proportion of product innovation that is new to the company for the services sector (Figure 7.5). However, the proportion of product innovation that is new to the market declined in both the manufacturing and services sectors, from 64.0% to 39.9% and from 27.0% to 23.9% respectively.

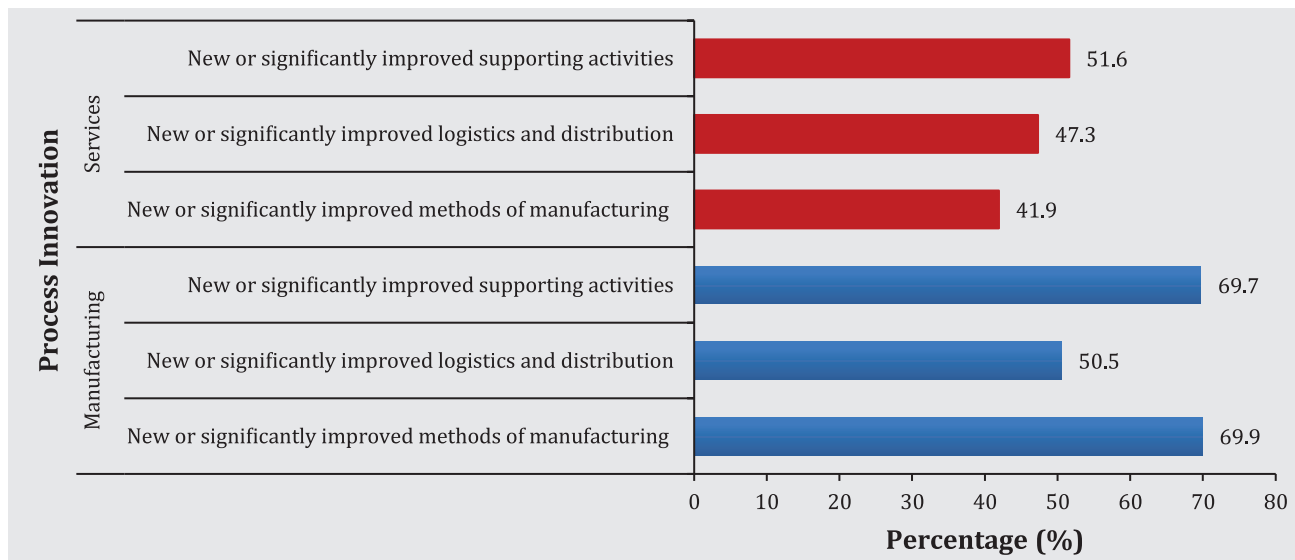
Figure 7.5 Novelty of Product Innovation by Sectors, 2012 and 2015

Source : National Survey of Innovation 2015

7.3.2 Process Innovation

Process innovation is defined as “the implementation of a new or significantly improved production or delivery method”. In the manufacturing sector, the majority of the process innovation is in the form of new or significantly improved methods of manufacturing or producing goods or services (69.9% of 469 companies), and new or significantly improved supporting activities such as maintenance systems or operations for purchasing, accounting or computing (69.7% of 469 companies). In the services sector, the majority of the process innovation is in the form of new or significantly improved supporting activities (51.6% of 744 companies) (Figure 7.6).

Figure 7.6 Process Innovation Activities by Sectors

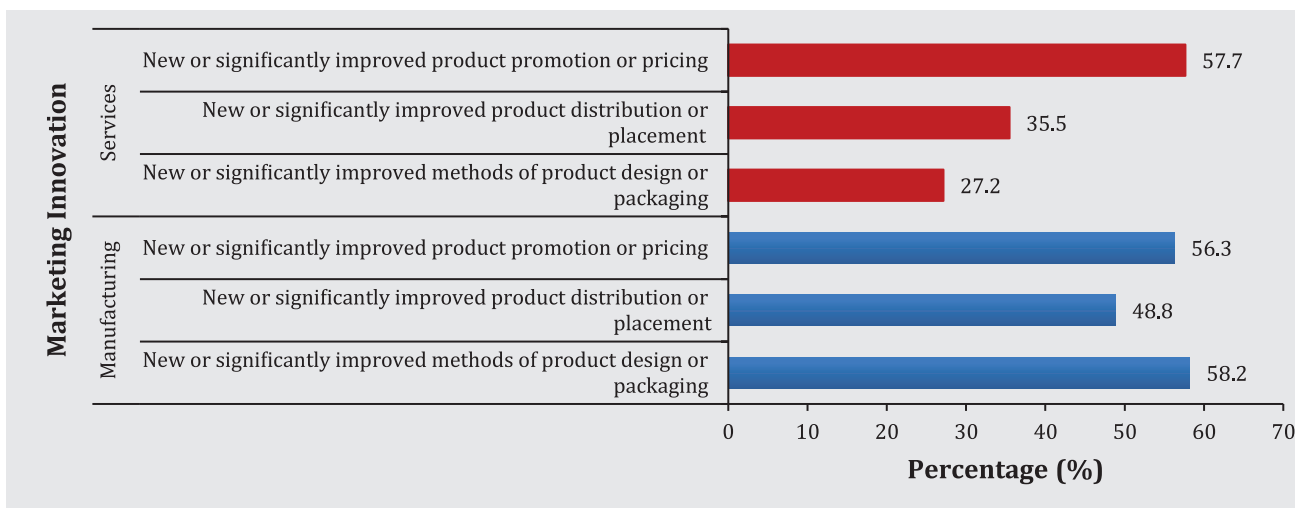


Source : National Survey of Innovation 2015

7.3.3 Marketing Innovation

Marketing innovation refers to the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion, or pricing. In the manufacturing sector, the majority of the marketing innovation is in the form of new or significantly improved methods of product design or packaging (58.2% of 469 companies) and new or significantly improved product promotion or pricing (56.3% of 469 companies) (Figure 7.7). Likewise, in the services sector the majority of the marketing innovation is in the form of new or significantly improved product promotion or pricing (57.7% of 744 companies). However, in contrast to the manufacturing sector, only 27.2% of the 744 companies in the services sector indicated marketing innovation in the form of new or significantly improved methods of product design or packaging.

Figure 7.7 Marketing Innovation Activities by Sectors

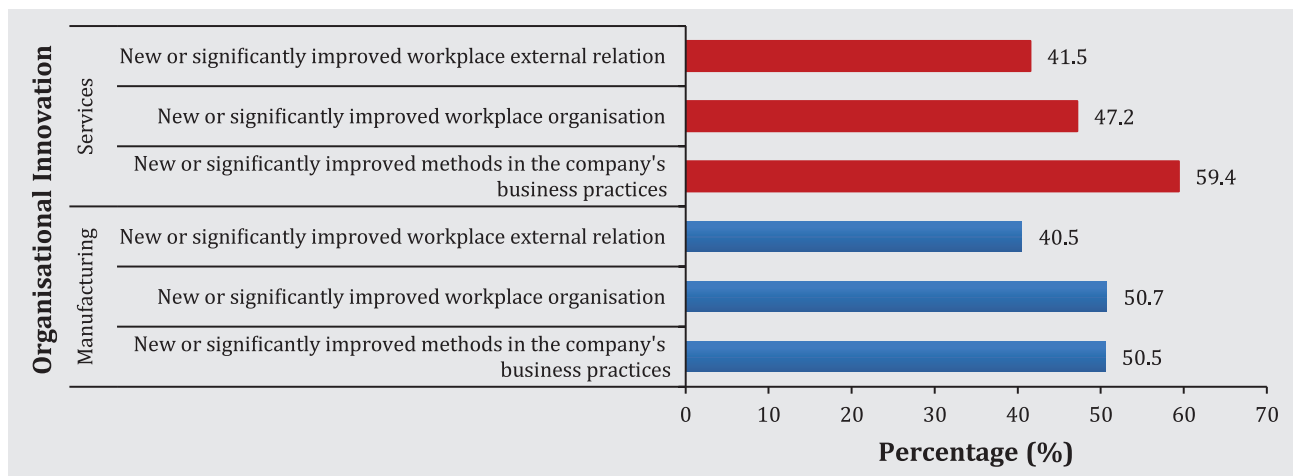


Source : National Survey of Innovation 2015

7.3.4 Organisational Innovation

Organisational innovation refers to “the implementation of a new organisational method within the company’s business practices, workplace organisation or external relations”. The majority of the organisational innovation in the manufacturing sector is in the form of new or significantly improved workplace organisation (50.7% of 469 companies) and new or significantly improved methods in the company’s business practices (50.5% of 469 companies). Organisational innovation in the services sector is mostly new or significantly improved methods in the company’s business practices (59.4% of 744 companies) (Figure 7.8).

Figure 7.8 Organisational Innovation Activities by Sectors

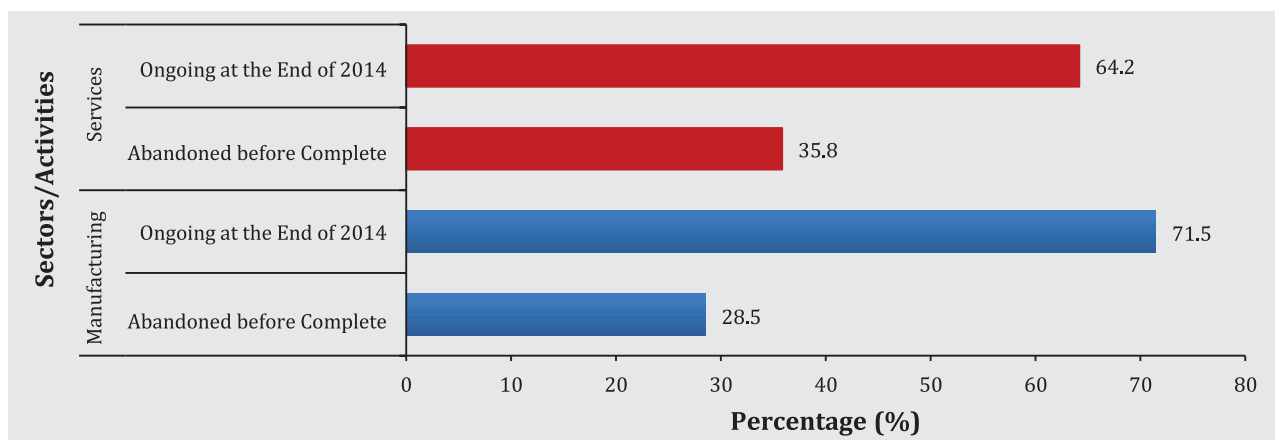


Source : National Survey of Innovation 2015

7.3.5 Abandoned and Ongoing Innovation Activities

There is a lower percentage of abandoned innovation activities in the period of 2012 – 2014 in the manufacturing sector (28.5%) compared to the services sector (35.8%) (Figure 7.9). Meanwhile, companies with ongoing innovation activities at the end of 2014 in the manufacturing and services sectors are 71.5% and 64.2% respectively.

Figure 7.9 Abandoned and Ongoing Innovation Activities

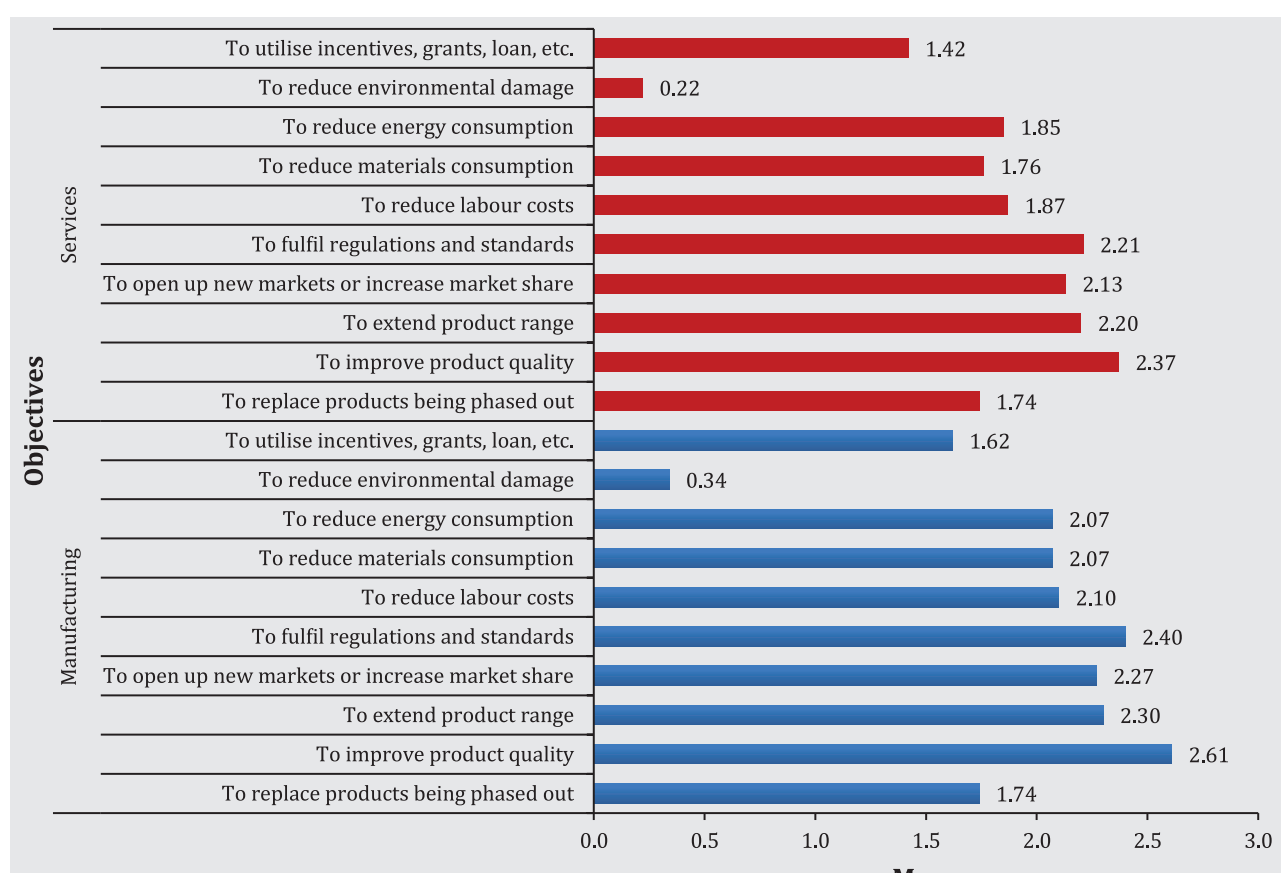


Source : National Survey of Innovation 2015

7.4 Objectives and Effects of Innovation

The main objective of the innovation activities in both the manufacturing and services sectors is to improve product quality, with mean scores of 2.61 and 2.37 respectively (Figure 7.10). The second most important objective is to fulfil regulations and standards. A markedly low degree of importance is placed on the objective of reducing environmental damage through innovation activities in both manufacturing (0.34) and services (0.22) sectors (Figure 7.10).

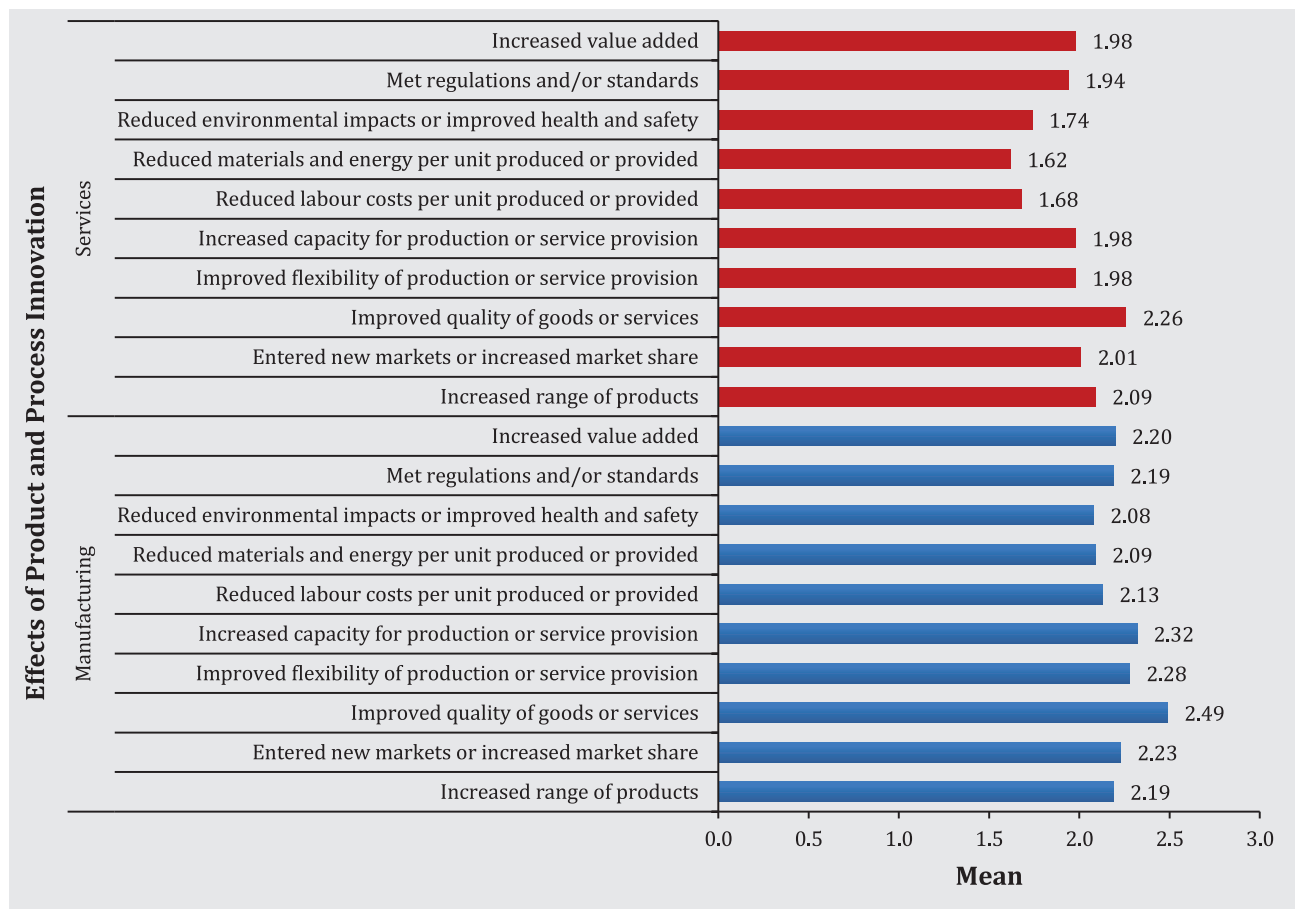
Figure 7.10 Degree of Importance of Objectives in Innovation Activities by Sectors



Note : Mean indicator: 0 = not relevant, 1 = least important, 2 = moderately important, 3 = highly important

Source : National Survey of Innovation 2015

Both manufacturing and services companies indicated that the highest impact of their product and process innovation is on the quality of goods or services, recording mean scores of 2.49 and 2.26 respectively (Figure 7.11). Other impacts include increased capacity for production or service provision, increased range of products, and entry to new markets or increased market share. Generally, the mean scores of product and process innovations impacts in the manufacturing sector are above 2.0. Lower impact is noticeable in most of the services sector, ranging between 1.6 and 2.0.

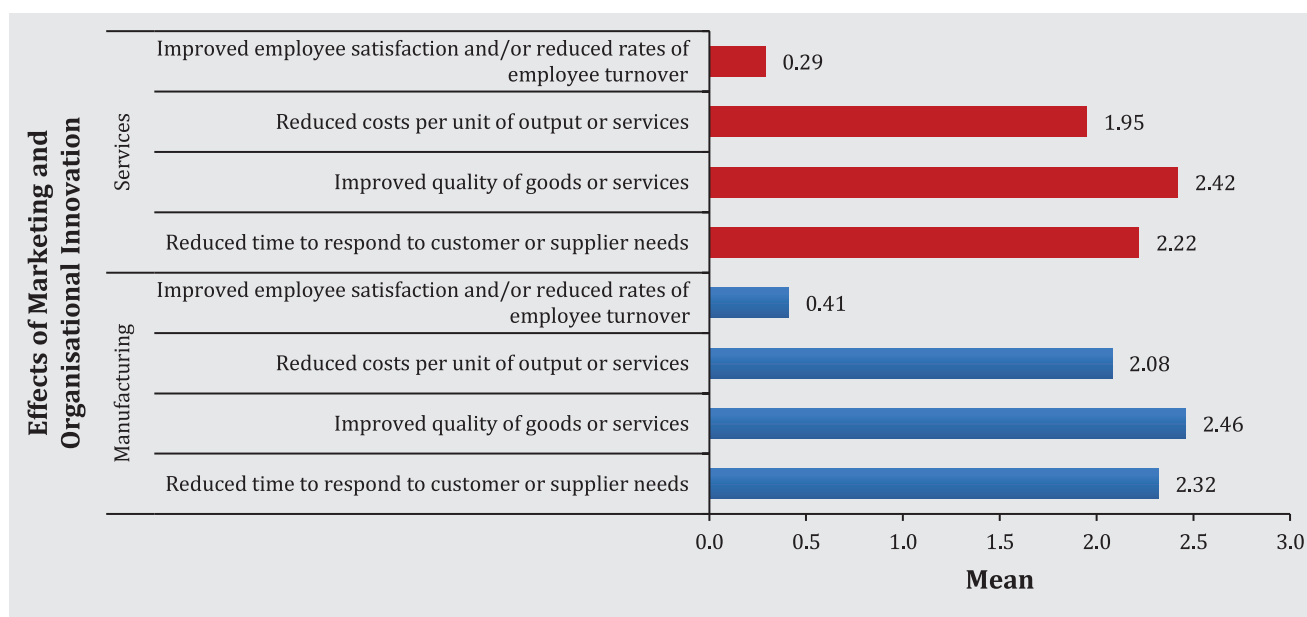
Figure 7.11 Effects of Product and Process Innovation by Sectors

Note : Mean indicator: 0 = not relevant, 1 = least important, 2 = moderately important, 3 = highly important

Source : National Survey of Innovation 2015

Improved quality of goods and services is seen as the most important effect of marketing and organisational innovations in both the manufacturing and services sectors, with mean scores of 2.46 and 2.42 respectively. It is also important in reducing the time to respond to customer or supplier needs (Figure 7.12). Marketing and organisational innovation has the least effect on improving employee satisfaction and/or reducing employee turnover rates in both manufacturing (0.41) and services (0.29) sectors.

Figure 7.12 Effects of Marketing and Organisational Innovation by Sectors



Note : Mean indicator: 0 = not relevant, 1 = least important, 2 = moderately important, 3 = highly important

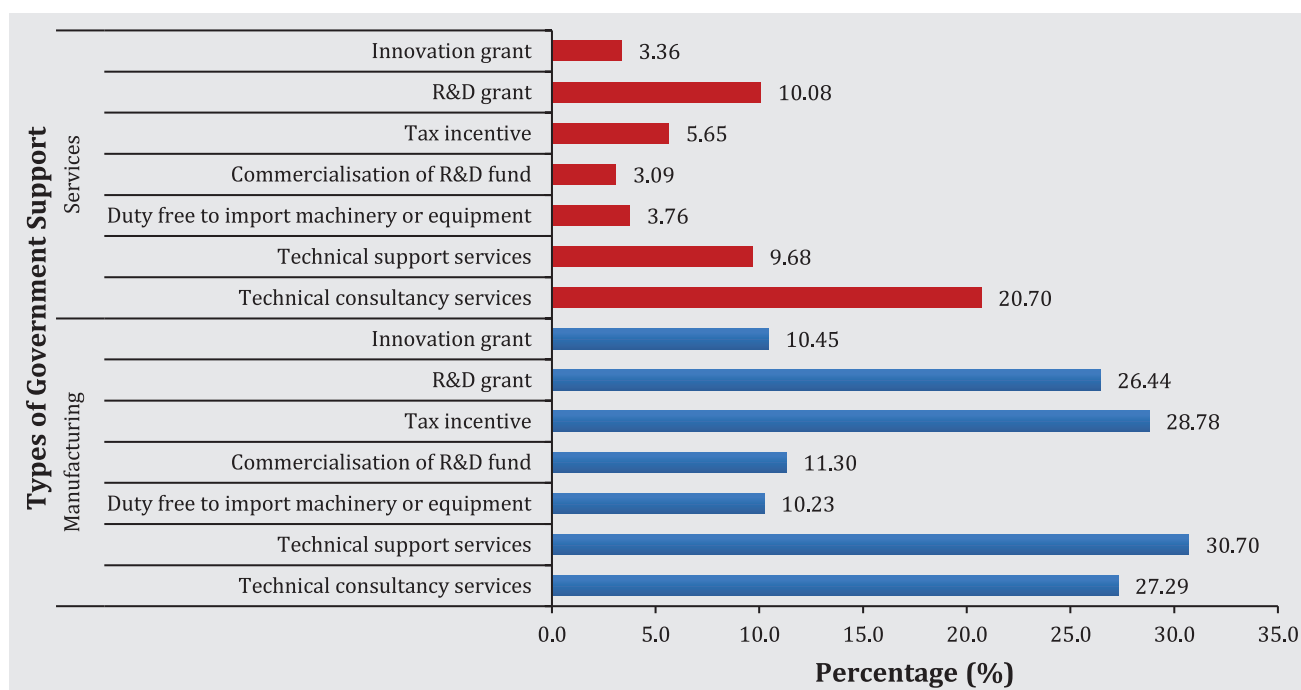
Source : National Survey of Innovation 2015

7.5 Resources for Innovation Activities

The following sections report on the government support, funding and sources of information for innovation activities in the manufacturing and services sectors.

7.5.1 Government Support

Only about one third or lower of the companies in both manufacturing and services sectors indicated that they received some form of government support as shown in Figure 7.13. In the manufacturing sector, most of the companies received technical support services (30.70%), followed by tax incentives (28.78%). In the services sector, companies received technical consultancy services (20.70%), followed by R&D grant (10.08%). 11.30% of the companies in the manufacturing sector indicated that they received commercialisation of R&D funds from the government. However, a lower percentage of companies (3.09%) in the services sector received these funds from the government. Overall, there is a lower percentage of companies in the services sector receiving government support in various forms compared to the companies in the manufacturing sector.

Figure 7.13 Types of Government Support for Innovation Activities by Sectors

Source : National Survey of Innovation 2015

7.5.2 Funding for Innovation Activities

The innovative companies in both the manufacturing and services sectors indicated that their main source of funding for innovation activities – across product, process, marketing, organisation and R&D innovations – is from their own sources (Table 7.4). The second highest source of funding for both sectors is from private sources such as subsidiaries, associated companies, other private non-financial enterprises, and financial companies.

Table 7.4 Funding of Innovation Activities

Source	Types of Innovation/Activity				
	Product	Process	Marketing	Organisation	R&D
Manufacturing Sector					
Own	381	346	319	289	192
Private	115	108	104	101	68
Public	45	44	36	40	34
Others	16	10	16	26	8
Services Sector					
Own	427	436	454	453	77
Private	218	177	182	167	54
Public	25	27	27	32	13
Others	27	14	16	20	18

Source : National Survey of Innovation 2015

7.5.3 Sources of Information for Innovation

The sources of information for innovation are categorised into four categories, namely: internal; market; institutional; and other sources. Based on the mean scores of Table 7.5 for both manufacturing and services sectors, market sources of information such as clients or suppliers have the highest degree of importance for obtaining information for innovation activities. Internal sources such as information from within the company are the next most important source of information for both sectors. Institutional sources such as universities, commercial laboratories and private R&D institutes are seen as the least important source of information for innovation activities in both sectors.

Table 7.5 Source of Information for Innovation Activities

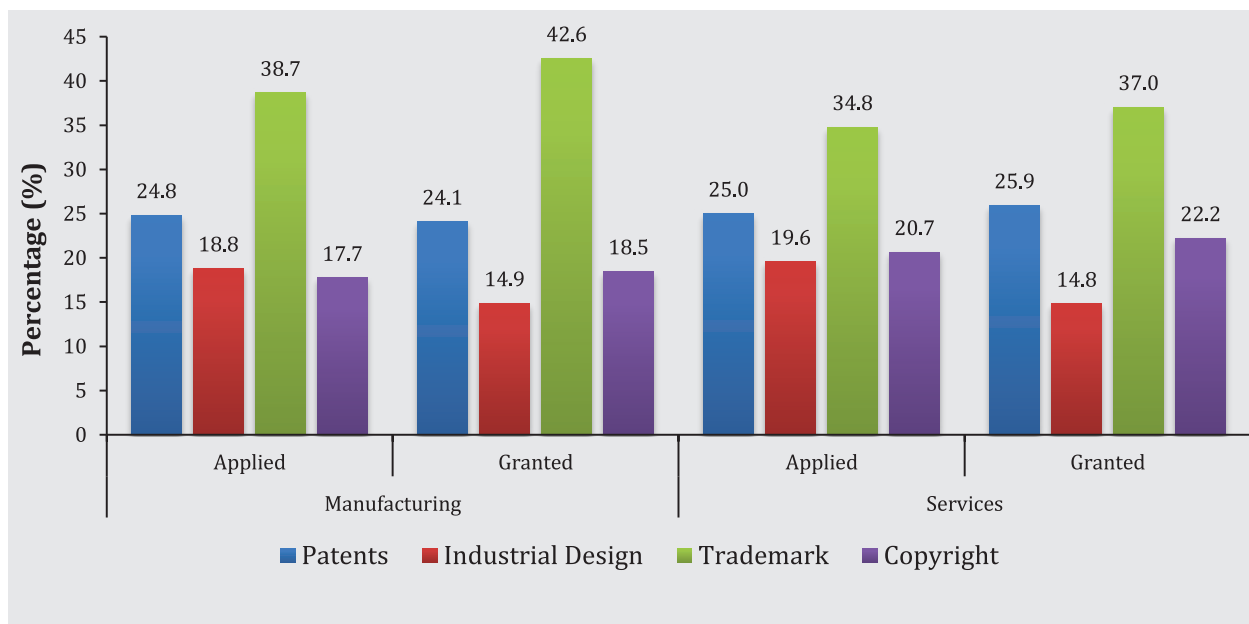
Sources of Information	Mean	
	Manufacturing	Services
Internal Sources		
Within the company	2.43	2.26
Other companies within the company group	1.78	1.88
Average Mean	2.11	2.07
Market Sources		
Suppliers of equipment, materials, services or software	2.30	2.30
Clients or customers	2.33	2.38
Competitors and other companies in the industry	1.99	2.24
Average Mean	2.21	2.31
Institutional Sources		
Consultants	1.48	1.46
Commercial laboratories and private R&D institutes	1.42	1.28
Universities or other higher education institutes	1.25	1.31
Government or public research institutes	1.29	1.34
Average Mean	1.36	1.35
Other Sources		
Conferences, trade fairs, exhibitions	1.89	1.62
Scientific journals and trade/technical publications	1.42	1.33
Professional and industry associations	1.48	1.37
Technical, industry or service standards	1.65	1.48
Average Mean	1.61	1.45

Note : Mean indicator: 0 = not relevant, 1 = least important, 2 = moderately important, 3 = highly important
 Source : National Survey of Innovation 2015

7.6 Intellectual Property and Protection

The number of intellectual properties such as patents, industrial designs, trademarks and copyrights applied for and granted can be seen as the outcome of innovation. In both manufacturing and services sectors, trademarks is the most common intellectual property followed by patents (Figure 7.14). This is similar to the findings of the NSI-2012 survey. Figure 7.14 indicates a higher percentage of companies in the services sector (20.7%) applied for copyrights compared to the manufacturing sector (17.7%). Similarly, a higher percentage of companies in the services sector (22.2%) have copyrights granted compared to the manufacturing sector (18.5%).

Figure 7.14 Intellectual Properties Applied and Granted by Sectors



Source : National Survey of Innovation 2015

7.7 Factors Hampering Innovation Activities

Similar to the NSI-2012 survey, the cost factor remains the most important factor hampering innovation activities in both manufacturing and services sectors in 2015. Regardless of sector, companies generally agree that the cost of innovation is too high (mean score of 2.37). Other cost factors are the lack of funds within the organisation as well as the lack of finance from sources outside the organisation. Based on mean scores, the knowledge factor is the next most important factor that hampers innovation activities, followed by the market factor (Table 7.6).

Table 7.6 Factors Hampering Innovation Activities

Factors	Mean	
	Manufacturing	Services
Cost Factor		
Cost too high	2.37	2.37
Lack of funds within the organisation	2.17	2.25
Lack of finance from sources outside the organisation	2.15	2.17
Excessive perceived risk	1.93	2.09
Average Mean	2.16	2.22
Knowledge Factor		
Lack of qualified personnel	2.11	2.15
Lack of information on technology	2.04	2.19
Lack of information on markets	1.94	2.13
Difficulties in finding cooperation partners for innovation	2.00	2.10
Weakness of intellectual property knowledge and rights	1.87	1.99
Average Mean	2.00	2.11
Market Factor		
Market dominated by established enterprise	2.10	2.12
Uncertain demand for innovative goods and services	2.02	1.96
Innovation is easy to imitate	1.87	1.92
Average Mean	2.00	2.00
Organisational Factor		
Attitude of personnel towards change	2.02	1.94
Attitude of managers toward change	1.97	1.94
Managerial structure of enterprise	1.93	1.94
Inability to devote staff to innovation activities due to production requirements	1.96	1.90
Lack of infrastructure (e.g. building)	1.93	1.94
Lack of facilities (e.g. machine, equipment)	2.09	2.02
Lack of networking with research institutions (e.g. Universities, SIRIM, PORIM, FRIM, etc.)	2.04	1.84
Average Mean	2.00	1.93
Regulatory Factor / Public Policy		
Insufficient flexibilities of regulations or standards	1.79	1.73
Limitation of science and technology public policies	1.76	1.78
Average Mean	1.78	1.76
Other Factors		
No need to innovate due to earlier innovations	1.53	1.57
No need to innovate because of lack of demand for innovation	1.58	1.62
Average Mean	1.56	1.60

Note : Mean indicator: 0 = not relevant, 1 = least important, 2 = moderately important, 3 = highly important

Source : National Survey of Innovation 2015

In order to further improve the state of innovation especially among SMEs, the government through SME Corp. introduced the innovation certification for enterprise rating and transformation (1-InnoCERT) programme. This initiative is further illustrated as in Box 7.1 below.

Box 7.1 Innovation Certification for Enterprise Rating and Transformation (1-InnoCERT) Programme

Introduced in 2010, the Innovation Certification for Enterprise Rating and Transformation (1-InnoCERT) Programme aims to recognise and certify innovative enterprises and SMEs, as well as encourage entrepreneurs to venture into high technology and innovation-driven industries. More SMEs participating in such activities will eventually lead to them being more competitive, and this will help Malaysia in achieving its objective of becoming a high income nation by the year 2020. The certification awarded under the programme identifies and verifies innovative companies through an internationally-recognised innovation standard (OECD Oslo Manual V3), and the certification process is developed from a similar process practised in Korea's Innobiz (Innovation SME) Certification Programme. Certified companies under the programme will be given fast-track access when applying for incentives to fund and market their products and services as offered by the government. Since its inception in 2010, a total of 162 Small and Medium Enterprises (SMEs) have been certified with 1-InnoCERT upon the completion of both the online self-assessment and on-site innovation audit and verification by SIRIM QAS International Sdn. Bhd. Under this programme, the 1-InnoCERT certified SMEs become automatically eligible to participate in the annual SME Innovation Award recognised by SME Corp. Malaysia. The Award offers a RM1 million cash prize, certificate and trophy to the Most Innovative SME, while winners of the six categories will each receive a RM200,000 cash prize, certificate and trophy. In addition, these SMEs will also be able to enjoy incentives offered by the Ministry of Finance (MoF) under its Green Lane Policy (GLP) which aims to speed up and ease the doing of business. These GLP Facilities include:

- i. Financing Facility – By way of 2% interest subsidy every year, subject to the maximum sum amount of RM200,000 annually or cumulative amount of RM1,000,000 for five years for each company, from the development institutes' development finance institutions / banks approved by MoF;
- ii. Tax Incentive – Exemption of stamp duty for the legal documentation under the loans, and single deduction on costs related to 1-InnoCERT certification fees for the first time;
- iii. Government Procurement – Registration of company for manufacturer status with the MoF may be approved without the requirement for site visits;
- iv. Additional bonus points on technical assessment;
- v. Priority to participate in the government offset programmes and consideration to be included in the Central Contract / Panel System Contract; and
- vi. Privileges in the Ministry of Finance incorporated Companies' Procurement as well as priority given in procurement activities done by MoF Incorporated Companies.

To further facilitate SMEs, starting in 2013 SME Corp. Malaysia provides an incentive in the form of the Innovation Voucher for SMEs that are 1-InnoCERT certified. This Innovation Voucher is a promissory note of reimbursable grant to facilitate SMEs with 1-InnoCERT in conducting innovation development and research & development (R&D), advertising & promotion, certification & quality management system (QMS), as well as packaging. As at 31 December 2015, a total of 4 companies had received financial incentives amounting to RM6.78 million under the Green Lane Policy. To date, RM45 million worth of Innovation Vouchers has been allocated for 1-InnoCERT qualified companies to facilitate activities including: R&D; Advertisement & Promotion; Certification & Quality Management System; Packaging; and Enhancement of Product, Process, and Production Capacity. In the effort to expand the number of high growth and innovative companies, one of the key decisions made during the 20th National SME Development Council (NSDC) held on 23 June 2016 was to endorse the adoption of 1-InnoCERT as the National Innovation Assessment Mechanism among Ministries and Agencies for selection and recognition of innovative SMEs.

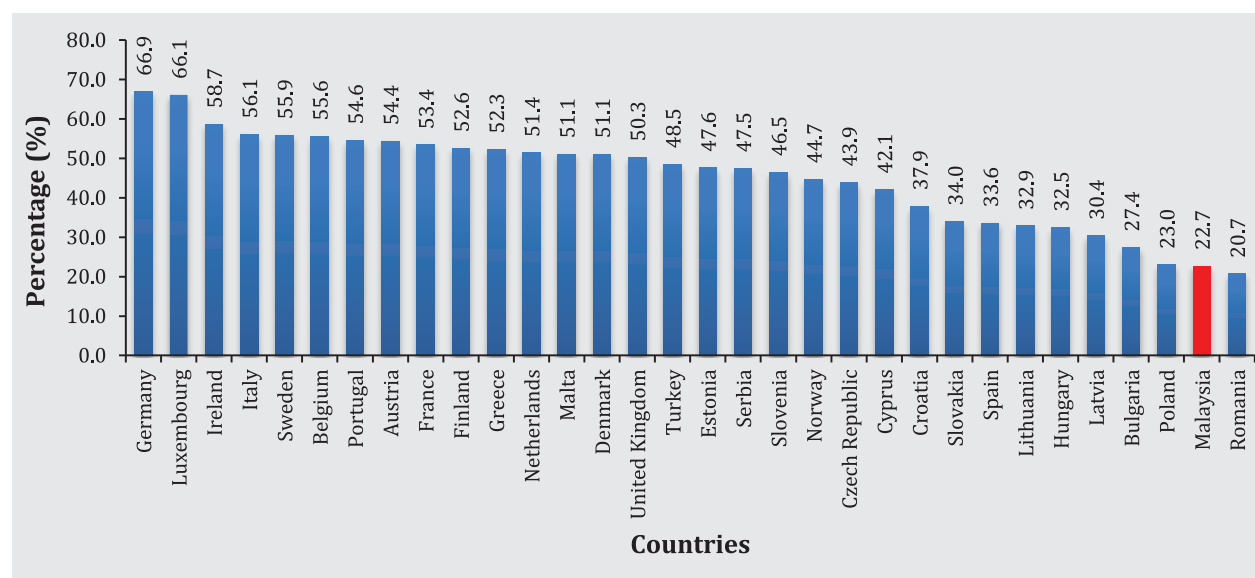
7.8 International Comparison

This section assesses and compares the innovation performance of Malaysia and other selected countries at the company and country levels. Comparable survey results as well as other national indicators of innovation are used.

7.8.1 Community Innovation Survey

The Community Innovation Survey (CIS) 2016 covers the data in the period 2010 – 2012, while the NSI-2015 covers the period 2012 – 2014. Nevertheless, CIS 2016 will be used as the basis for comparison of innovations between Malaysia and the EU. Figure 7.15 shows that Malaysia in 31st place has three times smaller percentage of innovative companies compared to Germany, the top ranking EU country.

Figure 7.15 Percentage of Innovative Companies by Countries



Note : Data coverage for the EU is from 2010 – 2012 and for Malaysia is from 2012 – 2014

Source : National Survey of Innovation 2015; Community Innovation Survey 2016

Among the four types of innovation, Table 7.7 shows that Malaysia achieves better rankings for process innovation (8th), followed by marketing innovation (17th), product innovation (18th) and organisational innovation (18th).

Table 7.7 Percentage of Innovative Companies by Types of Innovation

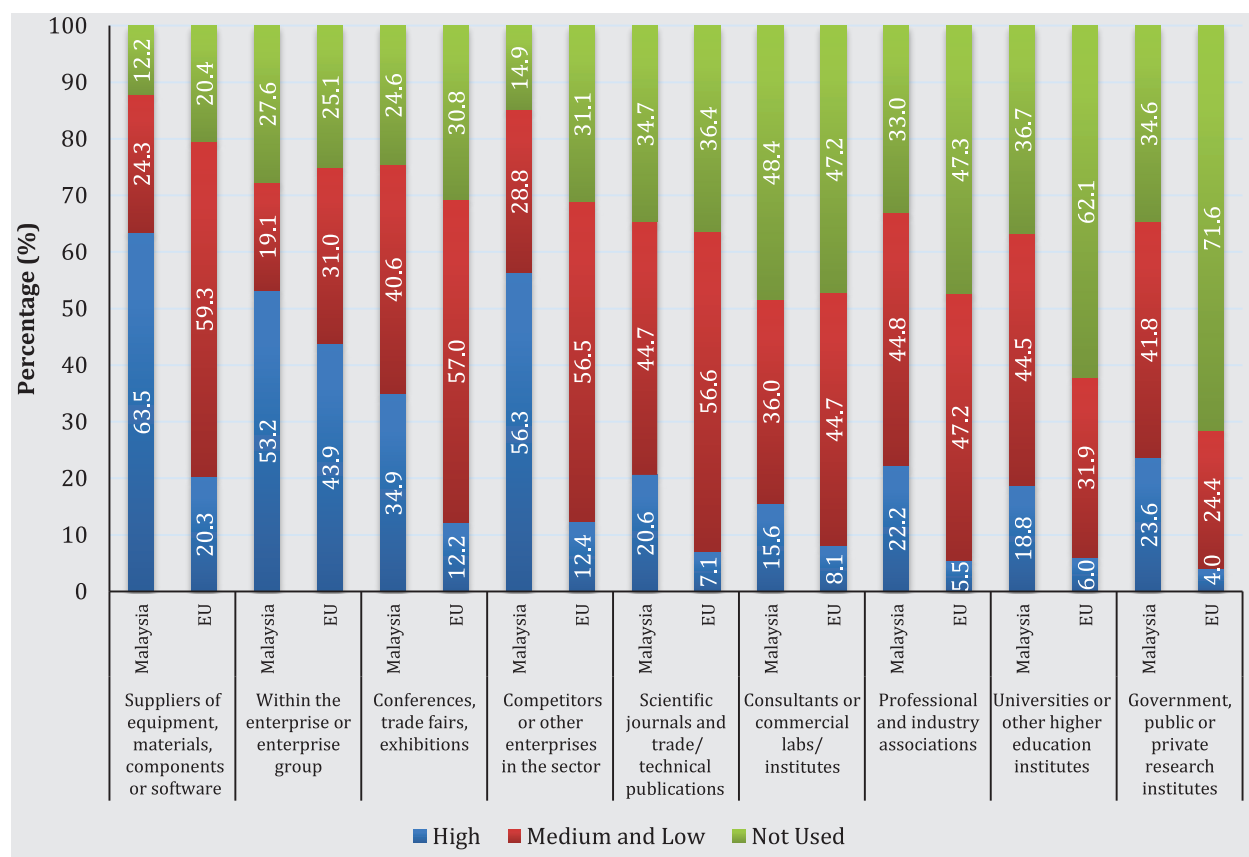
No.	Product Innovation		Process Innovation		Organisational Innovation		Marketing Innovation	
	Countries	(%)	Countries	(%)	Countries	(%)	Countries	(%)
1	Germany	35.8	Portugal	33.5	Luxembourg	46.8	Greece	36.8
2	Netherlands	31.9	Luxembourg	32.8	Austria	36.4	Ireland	35.7
3	Sweden	31.5	Belgium	31.1	Malta	34.7	Turkey	34.7
4	Belgium	31.5	Italy	30.4	France	34.2	Germany	34.4
5	Finland	31.0	Finland	29.3	United Kingdom	34.2	Portugal	32.8
6	Luxembourg	30.3	Austria	28.7	Italy	33.5	Malta	32.6
7	Italy	29.1	Cyprus	28.2	Portugal	32.8	Luxembourg	32.4
8	Ireland	27.8	Malaysia	27.9	Serbia	32.6	Serbia	32.2
9	Austria	26.6	Malta	26.4	Germany	32.2	Italy	31.0
10	Portugal	26.0	Ireland	25.9	Denmark	32.2	Sweden	30.4
11	Czech Republic	25.3	Netherlands	25.9	Turkey	31.7	Austria	29.5
12	Denmark	24.8	Greece	25.6	Greece	30.2	Cyprus	29.5
13	Serbia	24.5	Germany	25.5	Finland	29.7	Denmark	29.4
14	France	24.2	France	24.1	Belgium	29.3	Slovenia	28.5
15	United Kingdom	24.0	Czech Republic	24.0	Netherlands	27.3	Finland	26.5
16	Malta	23.9	Sweden	23.9	Slovenia	26.3	France	25.4
17	Slovenia	23.6	Estonia	23.8	Cyprus	26.2	Malaysia	23.9
18	Malaysia	22.8	Denmark	22.9	Malaysia	25.4	Croatia	23.5
19	Cyprus	20.9	Slovenia	22.5	Sweden	25.3	Netherlands	23.2
20	Estonia	20.7	Serbia	22.0	Croatia	22.9	Norway	23.2
21	Greece	19.5	Turkey	20.4	Ireland	21.8	Czech Republic	22.4
22	Norway	19.1	Croatia	19.0	Estonia	21.7	Belgium	21.9
23	Turkey	17.7	Spain	15.1	Norway	21.7	Estonia	21.9
24	Croatia	16.4	United Kingdom	14.1	Czech Republic	20.5	Hungary	19.7
25	Slovakia	14.4	Slovakia	13.5	Spain	19.4	Slovakia	19.3
26	Lithuania	11.6	Lithuania	13.1	Slovakia	18.6	Lithuania	19.3
27	Bulgaria	10.8	Latvia	12.7	Lithuania	17.5	United Kingdom	16.8
28	Hungary	10.6	Norway	11.9	Latvia	16.9	Latvia	16.5
29	Spain	10.5	Poland	11.0	Hungary	16.5	Bulgaria	14.2
30	Latvia	10.4	Bulgaria	9.3	Romania	14.1	Romania	13.8
31	Poland	9.4	Hungary	8.3	Bulgaria	12.4	Spain	13.2
32	Romania	3.4	Romania	4.6	Poland	10.4	Poland	10.6

Note : Data coverage for the EU is from 2010 – 2012, and for Malaysia is from 2012 – 2014

Source : National Survey of Innovation 2015; Community Innovation Survey 2016

Malaysian companies placed a high degree of importance on the information for product and/or process innovations from their suppliers of equipment, materials, components or software, as well as from their competitors or other enterprises in the sector (Figure 7.16). However, this is not the case with their EU counterparts, who placed a higher degree of importance on information from within their enterprise or enterprise group compared to external sources.

Figure 7.16 Sources of Information for Innovations by Degree of Importance



Note : Data coverage for the the EU is from 2010 – 2012, and for Malaysia is from 2012 – 2014
 Source : National Survey of Innovation 2015; Community Innovation Survey 2016

7.8.2 Global Competitiveness Index

As a whole, Malaysia’s competitiveness is ranked at the 18th position – advancing two positions from the previous Global Competitiveness Index (GCI) 2014 – 2015 survey (Table 7.8), and therefore one of the top 20 most competitive economies globally. Regionally, Malaysia is in a better position compared to Thailand (32nd) and Indonesia (37th), but far below Singapore (2nd). Switzerland is ranked 1st, while the United States is ranked 3rd. Malaysia is also ranked as more competitive than Australia (21st), Korea (26th) and China (28th).

Table 7.8 Global Competitiveness Index Rankings for Selected Countries

Country	2014-2015		2015-2016	
	Rank	Score	Rank	Score
Switzerland	1	5.70	1	5.80
Singapore	2	5.65	2	5.68
United States	3	5.54	3	5.61
Germany	5	5.49	4	5.53
Netherlands	8	5.45	5	5.50
Japan	6	5.47	6	5.47
Hong Kong	7	5.46	7	5.46
Finland	4	5.50	8	5.45
Sweden	10	5.41	9	5.43
United Kingdom	9	5.41	10	5.43
Taiwan	14	5.25	15	5.28
Malaysia	20	5.16	18	5.23
Australia	22	5.08	21	5.15
Korea Republic	26	4.96	26	4.99
China	28	4.89	28	4.89
Thailand	31	4.66	32	4.64
Indonesia	34	4.52	37	4.52

Note : Ranking over 144 countries (2014 – 2015); 140 countries (2015 – 2016)

Source : Global Competitiveness Report 2014 – 2015; Global Competitiveness Report 2015 – 2016

Nations are also ranked according to the innovation, business sophistication (BS), and innovation and business sophistication (IBS) factors. Table 7.9 shows that Switzerland is ranked 1st for all three factors. Japan, Germany and the United States are ranked 2nd, 3rd and 4th for both the BS and IBS factors, while Finland is ranked 2nd for innovation factor. Malaysia is ranked 20th, 13th and 17th for the innovation, BS and IBS factors respectively. Malaysia's rankings are better than those of Australia, China, Thailand and Indonesia. Malaysia is ranked higher than Singapore (18th) in BS.

Table 7.9 Ranking of Innovation and Business Sophistication

Country	GCI	Innovation		BS		IBS	
	Rank	Rank	Score	Rank	Score	Rank	Score
Switzerland	1	1	5.76	1	5.79	1	5.78
Singapore	2	9	5.24	18	5.13	11	5.19
United States	3	4	5.58	4	5.60	4	5.59
Germany	4	6	5.51	3	5.70	3	5.61
Netherlands	5	8	5.37	5	5.56	6	5.46
Japan	6	5	5.54	2	5.77	2	5.66
Hong Kong	7	27	4.40	16	5.20	23	4.80
Finland	8	2	5.73	14	5.28	5	5.50
Sweden	9	7	5.46	7	5.44	7	5.45
United Kingdom	10	12	5.02	6	5.54	9	5.28
Taiwan	15	11	5.10	21	5.01	16	5.06
Malaysia	18	20	4.82	13	5.29	17	5.05
Australia	21	23	4.53	27	4.70	26	4.61
Korea Republic	26	19	4.83	26	4.80	22	4.82
China	28	31	3.89	38	4.32	34	4.11
Thailand	32	57	3.41	35	4.36	48	3.88
Indonesia	37	30	3.94	36	4.35	33	4.14

Note : BS – Business Sophistication; IBS – Innovation and Business Sophistication
Source : Global Competitiveness Report 2015 – 2016

7.8.3 Global Innovation Index (GII)

Malaysia's rank improved one position from 33rd in GII 2014 to 32nd in GII 2015, but ranked 35th in GII 2016 (Table 7.10). Malaysia is ranked higher than Thailand (52nd) and Indonesia (88th), but lower than Singapore (6th) in GII 2016. Switzerland, Sweden and the United Kingdom remain the top 3 most innovative nations globally from 2014 to 2016.

Table 7.10 Global Innovation Index Rankings, 2014, 2015, and 2016

Country	GII 2014 Rank	GII 2015 Rank	GII 2016 Rank
Switzerland	1	1	1
Sweden	3	3	2
United Kingdom	2	2	3
United States	6	5	4
Finland	4	6	5
Singapore	7	7	6
Ireland	11	8	7
Denmark	8	10	8
Netherlands	5	4	9
Germany	13	12	10
Korea Republic	16	14	11
Luxembourg	9	9	12
Japan	21	19	16
Australia	20	17	19
China	29	29	25
Malaysia	33	32	35
Thailand	48	55	52
India	76	81	66
Indonesia	87	97	88

Note : Ranking over 141 countries (2014); 141 countries (2015); 128 countries (2016)

Source : Global Innovation Index 2014; Global Innovation Index 2015; Global Innovation Index 2016

7.8.4 Innovation Efficiency Ratio (IER)

The IER measures the nation's innovation efficiency based on their income as well as their regional groups. The ratio indicates to what degree inputs are efficiently transformed into innovation outputs. Table 7.11 exhibits the innovation efficiency ratio and ranking for selected countries. Switzerland, the United States and Singapore are ranked 1st in terms of GII rank in their respective regional groups, but ranked 5th, 25th and 78th in terms of efficiency ratio among all economies. Malaysia is ranked 8th, a position below China (7th) in the Southeast Asia & Oceania region group. However, globally Malaysia is ranked 59th in terms of efficiency ratio, after Indonesia (52nd) and Thailand (53rd). In GII 2015, Malaysia was ranked 56th in terms of efficiency ratio.

Table 7.11 Innovation Efficiency Ratio Ranking

Country	Efficiency Ratio	Efficiency Rank	Region Group	GII Rank in Region Group
Upper Middle-Income Economies				
China	0.90	7	SEAO	7
Thailand	0.70	53	SEAO	9
Malaysia	0.67	59	SEAO	8
Lower Middle-Income Economies				
Moldova, the Republic of	0.94	4	EUR	30
Indonesia	0.71	52	SEAO	13
High Income Economies				
Luxembourg	1.02	1	EUR	9
Malta	0.98	2	EUR	16
Iceland	0.98	3	EUR	10
Switzerland	0.94	5	EUR	1
Estonia	0.91	6	EUR	15
Ireland	0.89	8	EUR	5
Germany	0.87	9	EUR	8
Sweden	0.86	10	EUR	2
United Kingdom	0.83	14	EUR	3
Korea Republic	0.8	24	SEAO	2
United States	0.79	25	NAC	1
Finland	0.75	32	EUR	4
Japan	0.65	65	SEAO	4
Australia	0.64	73	SEAO	6
Singapore	0.62	78	SEAO	1

Note : SEAO – Southeast Asia & Oceania; EUR – Europe; NAC – North America

Source : Global Innovation Index 2016

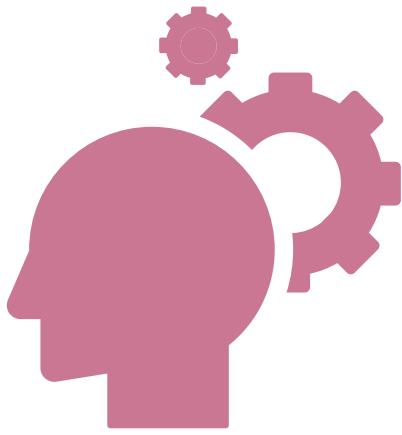
7.9 Summary

Innovation is essential for sustainable economic growth as well as to enhance the nation's competitiveness. The NSI-2015 survey indicates that about three quarters of the companies from the services sector are innovative, while slightly more than two thirds in the manufacturing sector are innovative. The services sector appears to be more innovative compared to the manufacturing sector.

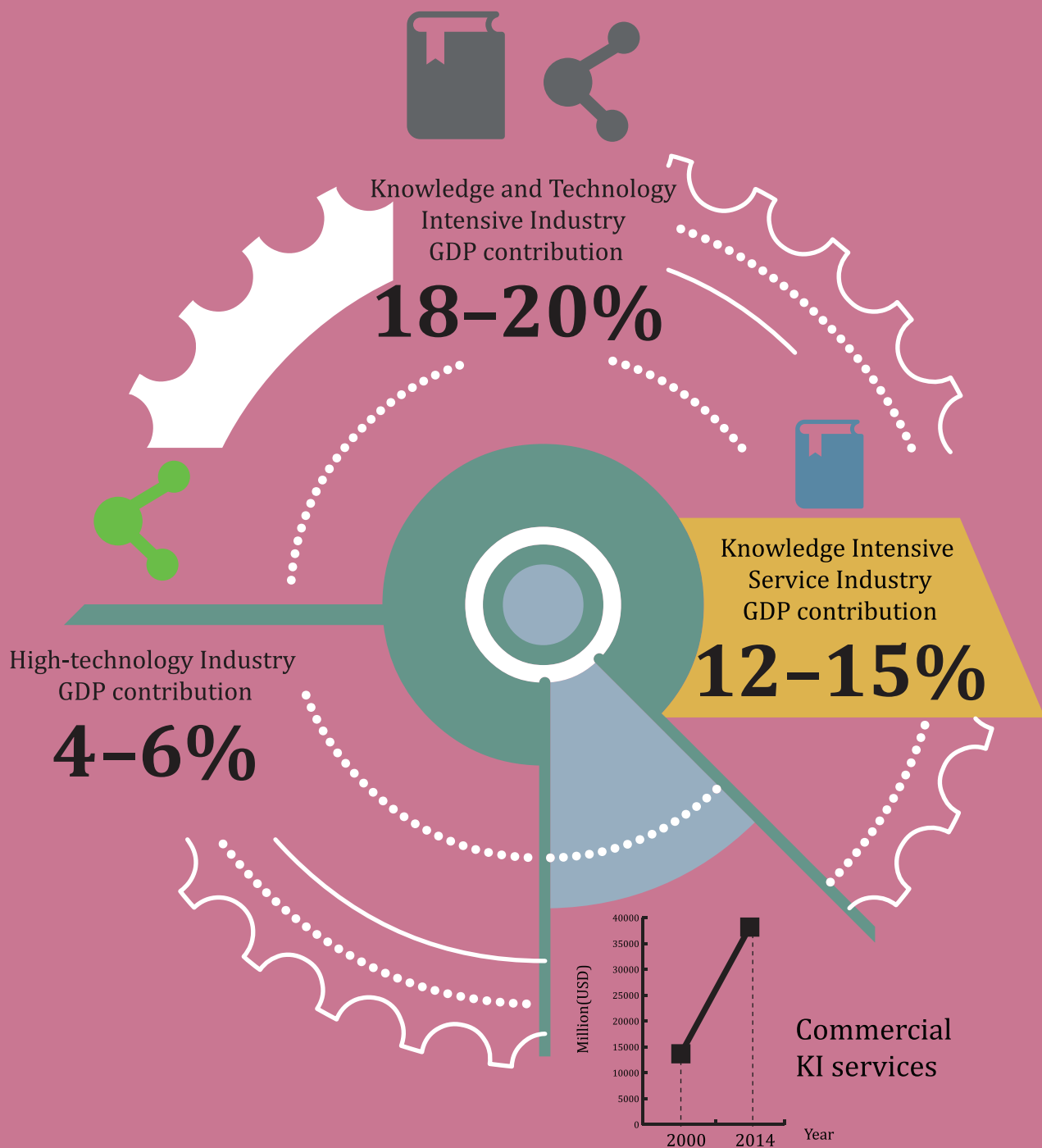
Innovative companies in both manufacturing and services sectors are mostly private limited companies or under sole proprietorship. Few of these innovative companies are public limited companies. Also, a large percentage of innovative companies are small companies. Innovative companies in both sectors typically record annual sales of more than RM6,000,000. Nevertheless, compared to the manufacturing sector a higher proportion of innovative companies in the services sector are able to record more than RM5,000,000 in annual sales. In addition, innovative companies in the services sector also generally have lower expenditures compared to the manufacturing sector.

Most of the product innovation is only new to the company, indicating limited novelty. Less than 1% of the companies in both sectors indicated having product innovation that is new to the world. In comparison to the NSI-2012 survey, an increase in proportion of product innovation that is only new to the company is noticed in NSI-2015. The main objective of innovation activities in both the manufacturing and services sectors is to improve product quality, followed by the aim of fulfilling regulations and standards. Notably low degree of importance is placed on reducing environmental damage through innovation activities in both sectors. Additionally, only about one third or lower of the companies in both manufacturing and services sectors indicated that they received some form of government support. There is a higher proportion of companies in the manufacturing sector receiving tax incentives from the government compared to the services sector. Nevertheless, similar to the NSI-2012 findings, NSI-2015 indicated cost factor as the main hampering factor for innovation activities in both manufacturing and services sectors. Cost of innovation is too high and there is a lack of funds to finance innovation activities. Knowledge factor is the next most important factor hampering innovation activities in both sectors.

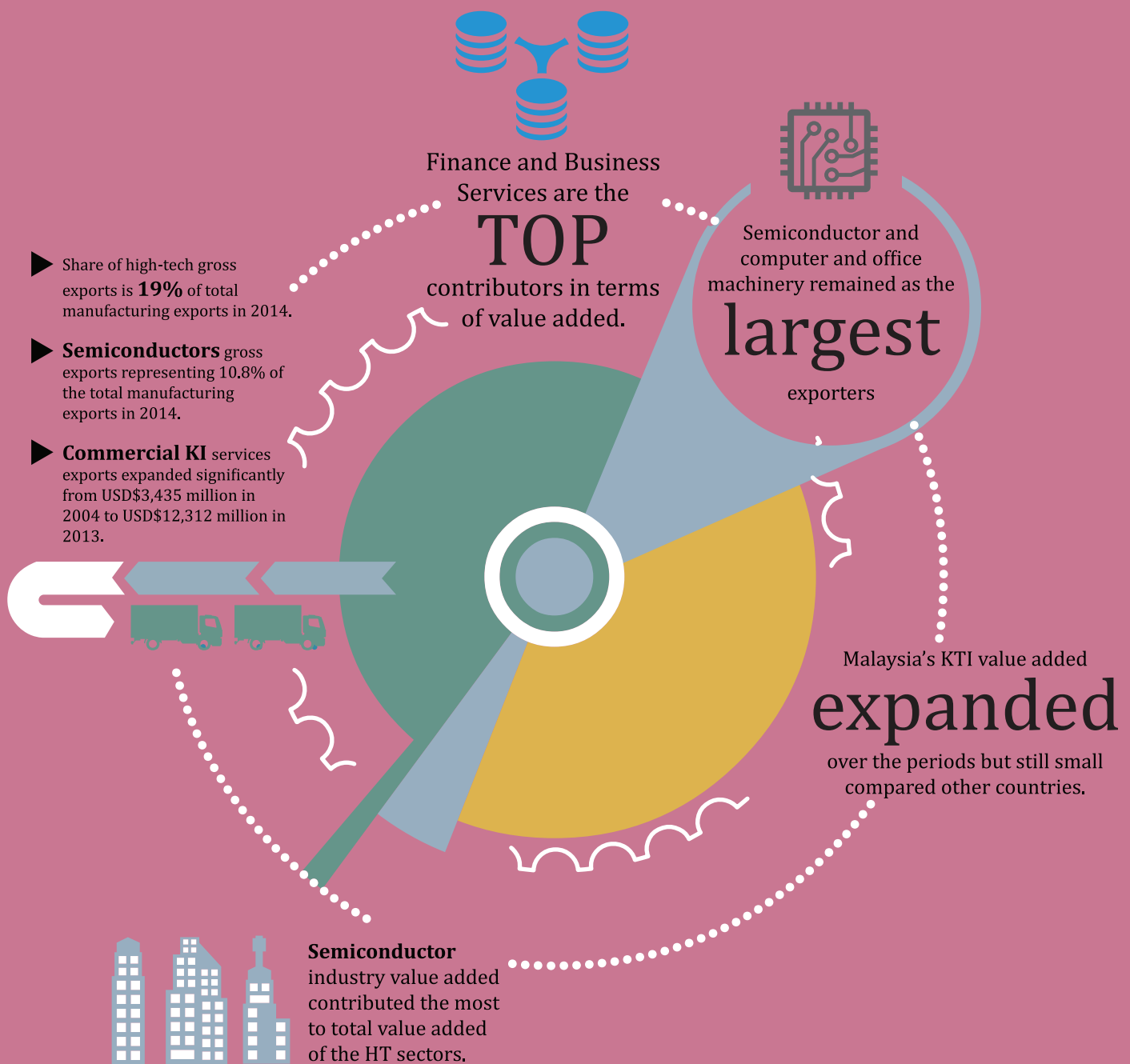
Internationally, Malaysia is among the top 20 most competitive economies globally, ranking 18th in GCI 2015-2016. Switzerland is ranked 1st, followed by Singapore. In GII 2016, Malaysia is ranked 35th – higher in ranking than Thailand (52nd) and Indonesia (88th), but lower than Singapore (6th). As for the innovation efficiency ratio in GII 2016, Malaysia is ranked 59th globally.

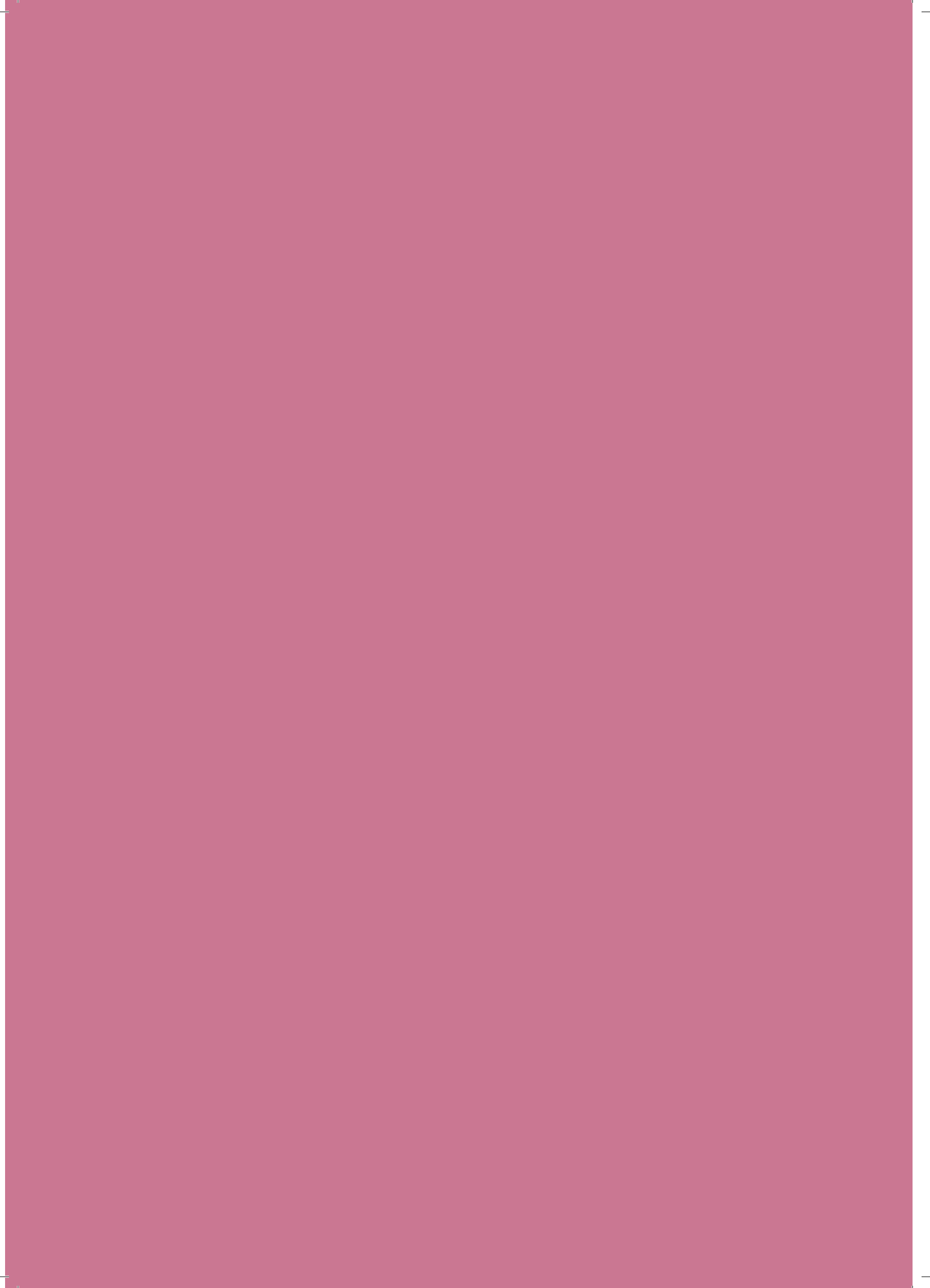


Knowledge and Technology Intensive Industries



▶▶ CHAPTER 8





CHAPTER 8: KNOWLEDGE AND TECHNOLOGY INTENSIVE INDUSTRIES

8.1 Introduction

In order to promote economic growth and competitiveness, policymakers globally as a whole have emphasised R&D and other advancements in STI knowledge. Malaysia has aspired to transform the economic structure across all sectors and move into higher value added, technology and knowledge intensive activities. This is important in order for Malaysia to achieve its aspiration of attaining advanced economy status by 2020. Knowledge intensive industry is defined as industry that focuses on high technology and skilled labour in order to drive technological innovations, while high-technology industries are classified as industries that have higher R&D intensity (Hansen and Serin, 1997).

This chapter obtains data from the US Science and Engineering Indicators 2016 report which covers two main areas, namely: the value added and the trade flows of high-technology (HT) industries; and knowledge-intensive (KI) service industries that represent the knowledge and technology-intensive (KTI) industries. Value added is defined as a value contributed via goods and services by a nation, firm and other entity minus the domestic and imported inputs and purchases. KI industries encompass commercially traded services including business, education, health and social services. Meanwhile, HT industries are represented by semiconductor, computers and office machinery, testing, measuring and control instruments, aircraft and spacecraft, and pharmaceuticals.

8.2 Malaysia's KTI Value Added

Table 8.1 demonstrates the share of KTI, HT and KI in Malaysia's GDP. KTI represents the total value added of KI and HI. The share has been consistent over the years, being in the range of 18 – 20% for KTI, 4 – 6% for HT and 12 – 15% for KI. The value added of these industries has grown steadily between 2005 and 2014. Indeed, within KTI the KI service value added has been the largest contributor (in the range of 12 – 15%) over the periods, followed by HT industry. In value terms, the KTI value added increased from USD28.3 billion in 2005, to USD63.1 billion in 2014. Meanwhile, HT and KI value added increased from USD8.04 billion and USD18.5 billion in 2005, to USD13.9 billion and USD44.4 billion in 2014 respectively.

Table 8.1 Malaysia's KTI Industries Value Added and Share in GDP

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Share of KTI in GDP (%)	20	20	20	18	20	20	19	19	20	19
Value Added KTI (USD Billion)	28.3	32.0	37.8	41.6	41.0	49.7	53.7	58.2	61.2	63.1
Share of HT in GDP (%)	6	5	5	4	4	5	4	4	4	4
Value Added HT (USD Billion)*	8.04	8.50	10.2	10.1	8.57	11.4	10.6	12.0	13.2	13.9
Share of KI in GDP (%)	13	13	13	12	15	14	13	14	14	14
Value Added Commercial KI (USD Billion)**	18.5	21.5	25.1	28.6	29.3	34.7	38.8	41.8	43.4	44.4

Note : *Includes aerospace, communications and semiconductors, computers and office machinery, pharmaceutical and scientific instruments, and measuring equipment. **Includes business, financial, communications, education and health.

Source : US Science and Engineering Indicators 2016

8.3 Malaysia's Knowledge Intensive Services Value Added

The value added for KI services increased by threefold, from USD11,782 million in 2000 to USD38,154 million in 2014 (Table 8.2). Malaysia's services sector has progressed steadily over the last decade, with commercial KI services expanding from USD13,649 million in 2000 to USD44,456 million in 2014. Among the commercial KI services, financial services contributed the most followed by business services, with USD23,075 million and USD10,277 million respectively in 2014. Malaysia's financial services industry plays a crucial role in driving economic growth, with an active private sector participation. Moreover, continued innovation of financial products and services are also crucial in raising the competitiveness of Malaysia's financial institutions. In terms of annual average value added growth, health and social services, education services and business services recorded significant growth of 37.39%, 32.21% and 23.75% respectively between 2010 and 2014. Overall, the KI services value added grew significantly over the years. A better business environment could facilitate the performance of the industries. The latest Doing Business 2015 (World Bank, 2015) revealed that Malaysia had improved its business environment during 2013 – 2014, improving its rank from 20th in 2013 to 18th in 2014.

Table 8.2 Malaysia's Knowledge Intensive Services Value Added, USD Million

Industry	2000	2010	2011	2012	2013	2014
Financial services	8,586	19,162	21,060	22,776	23,037	23,075
Business services	2,376	7,569	8,535	9,240	9,822	10,277
Health and social services	391	1,837	2,094	2,253	2,349	2,438
Education services	429	1,766	2,030	2,190	2,284	2,364
Total KI Services**	11,782	30,334	33,719	36,459	37,492	38,154
Commercial KI services*	13,649	34,729	38,765	41,815	43,394	44,456

Note : *Includes communications. **Includes financial, business, health, and social and education services only.

Source : US Science and Engineering Indicators 2016

8.4 Malaysia's High Technology Manufacturing Value Added

Table 8.3 reveals Malaysia's HT manufacturing products value added outputs. Among Malaysia's HT manufacturing, semiconductor industry contributed the most to the total value added of the HT sectors. The strong presence of foreign multinational semiconductor manufacturers has strongly contributed to the value added activities, especially those located in free trade zones such as Penang. Central and state governments have facilitated the development of the semiconductor cluster. Meanwhile, computer and office machinery remained the second largest value added contributor between 2000 and 2014, while testing, measuring and control instruments remained third largest. In Malaysia, both of these industries have performed relatively well. The contributions of the aircraft and spacecraft and the pharmaceutical industries were respectively only USD573 million and USD481 million in 2014. Overall, HT industries are losing their competitiveness, with the share significantly declining from 15% in 2000 to 10% in 2014.

Table 8.3 Malaysia's High Technology Manufacturing Value Added, USD Million

Industry	2000	2010	2011	2012	2013	2014
Semiconductor	4,962	6,573	5,995	6,803	8,017	8,403
Computers and Office Machinery	1,488	1,754	1,343	1,307	1,270	1,228
Testing, Measuring, and Control Instruments	334	682	752	831	907	861
Aircraft and Spacecraft	17	259	292	437	532	573
Pharmaceuticals	100	279	367	453	459	481
Total HT Manufacturing*	6,901	9,547	8,749	9,831	11,185	11,546
Share of HT in All Manufacturing	15%	10%	8%	9%	9%	10%

Note : *Excluding communications.

Source : US Science and Engineering Indicators 2016

8.5 Malaysia's KI Services Exports and Imports

Commercial KI services exports expanded significantly, from USD3,435 million in 2004 to USD12,312 million in 2013. Almost all the KI services exports increased between 2004 and 2013, with the exception being royalties and fees (Table 8.4). Other business services (USD8,624 million) contributed the most in KI services exports. The annual average export growth for computer and information services contributed the highest growth (53.28%), while financial services contributed the lowest (13.52%) among other KI services.

Table 8.4 Malaysia's KI Services Export by Sub-Sector, USD Million

KI Sectors	2004	2010	2011	2012	2013
Computer and information services	348	1,440	1,768	2,069	2,017
Financial services	377	439	725	754	836
Royalties and fees	42	101	149	136	102
Other business services	2,315	4,861	6,492	7,666	8,624
Commercial KI services*	3,435	7,429	9,639	11,344	12,312

Note : *Includes business, financial, communications, education and health

Source : US Science and Engineering Indicators 2016

A notable trend from 2004 to 2013 has been the increase in import value for KI services (Table 8.5). Commercial KI services imports have grown significantly to USD13,867 million in 2013. Other business services import values increased threefold, while computer and information services increased fivefold between 2004 and 2013. The annual average import growth of commercial KI services is 21.93% over the period of 2004 – 2013. Overall, Malaysia recorded a trade deficit in KI services.

Table 8.5 Malaysia's KI Services Imports, by Sub-Sector, USD Million

KI Sectors	2004	2010	2011	2012	2013
Computer and information services	325	1,059	1,197	1,462	1,683
Financial services	615	893	1,053	1,301	1,303
Royalties and fees	896	1,318	1,634	1,543	1,395
Other business services	3,219	6,233	7,533	8,329	9,381
Commercial KI services*	4,663	9,108	10,952	12,398	13,867

Note : *Includes business, financial, communications, education and health

Source : US Science and Engineering Indicators 2016

8.6 Malaysia's HT Industries Exports and Imports

Table 8.6 denotes Malaysia's share of HT manufacturing gross exports for the period of 2000 – 2014. The largest share of Malaysian HT exports comes from semiconductor products, representing 56.42% (USD 39,732 million) of total HT exports in 2014. The overall exports of all manufactured products expanded steadily over the period. Malaysia's share of HT exports over total manufacturing exports has been significantly declining over the years, from 33.25% in 2000 to 19.18% in 2014. Testing, measurement and control instruments, pharmaceutical and aircraft and spacecraft sectors recorded an impressive annual average export growth of 30.52%, 24.68% and 15.17% respectively over the 2000 – 2014 period. These industries can be new potential growth industries for Malaysia. Computers and office machinery annual average export growth deteriorated by 1.07%.

Table 8.6 Malaysia's HT Exports by Sub-Sector, USD Million

HT Sectors	2000	2010	2011	2012	2013	2014
Semiconductor	25,518	36,758	41,761	39,203	39,108	39,732
Computers and Office Machinery	24,366	26,672	22,049	20,278	19,898	20,695
Testing, Measuring, and Control Instruments	1,561	5,997	6,668	7,711	7,698	8,232
Aircraft and Spacecraft	401	874	1,012	1,077	1,129	1,253
Pharmaceuticals	112	449	410	461	461	499
Total Manufacturing Exports	156,249	311,036	353,684	351,350	339,098	367,060
Share of HT Exports in manufacturing (%)	33.25	22.75	20.33	19.56	20.14	19.18

Source : US Science and Engineering Indicators 2016

Table 8.7 illustrates the imports of HT sectors from 2000 and 2014, namely: semiconductors; testing, measuring, and control instruments; pharmaceuticals; computers and office machinery; and aircraft and spacecraft. The largest imports consist of semiconductors (in tandem with its exports as seen in Table 8.6), followed by computers and office machinery and testing, measuring and control instruments. The annual average import growth for HT industries is 3%. The share of HT imports (36.90% in 2000) declined since 2000 falling to 18.96% in 2014. Overall, Malaysia recorded a trade surplus in the HT sectors, namely semiconductors as well as computer and office machinery.

Table 8.7 Malaysia's HT Industries Import by Sub-Sector, USD Million

HT Sectors	2000	2010	2011	2012	2013	2014
Semiconductor	24,920	29,109	28,863	28,856	27,357	27,022
Computers and Office Machinery	4,178	7,625	7,261	6,854	6,874	7,268
Testing, Measuring, and Control Instruments	2,167	5,756	5,875	5,398	5,559	6,048
Aircraft and Spacecraft	603	2,626	3,226	4,890	5,664	5,938
Pharmaceuticals	319	1,162	1,347	1,484	1,509	1,551
Total Imports of Manufacturing	87,238	195,165	221,913	237,529	238,539	252,202
Share of HT Imports in Manufacturing (%)	36.90	23.71	20.99	19.99	19.69	18.96

Source : US Science and Engineering Indicators 2016

8.7 International Comparison

This section discusses the international comparison of the value added activities and trade performance of the HT and KI intensive industries in selected countries.

8.7.1 Value Added of KTI Industries in Selected Countries

Table 8.8 shows the world value added for knowledge and technology-intensive (KTI) industries which has been accelerating steadily from 2000 to 2014. At 32.1%, the United States leads the world's KTI value added, followed by the European Union (26%) and China (10.3%). Although Malaysia's KTI value added expanded over the same time frame, it is still small compared to other countries – hence Malaysia should further increase its value added activities. Both Malaysia's and the Philippines' contributions were low (0.3% each) in the world's KTI value added. The United States and Singapore retain the lead in terms of GDP share (39% each) over the European Union and Japan (30% each). The Philippines (26%) takes the lead in Southeast Asia excluding Singapore, in terms of KTI share in GDP – this is in contrast to others in the region including Indonesia (12%), Malaysia (19%) and Thailand (21%).

Table 8.8 Value Added of KTI Industries in Selected Countries, 2000 – 2014

Country	KTI Value Added (USD Million)						% of World Value Added	% of GDP
	2000	2010	2011	2012	2013	2014	2014	2014
World	9,493,268	18,148,160	19,687,319	20,107,722	20,665,024	21,348,911	-	27
United States	3,817,901	5,792,033	5,974,900	6,254,255	6,514,167	6,851,592	32.1	39
EU	2,428,070	5,042,685	5,401,613	5,132,975	5,365,617	5,546,047	26.0	30
China	253,953	1,266,332	1,548,714	1,783,602	2,012,131	2,194,928	10.3	21
Japan	1,348,998	1,621,522	1,761,764	1,768,098	1,445,675	1,373,530	6.4	30
South Korea	135,780	310,094	328,501	333,753	314,836	334,647	1.6	24
Taiwan	97,956	144,087	158,291	162,568	165,762	170,930	0.8	32
Brazil	124,822	420,745	482,784	441,134	445,324	441,214	2.1	19
Singapore	38,601	91,592	104,983	111,374	117,679	121,387	0.6	39
India	82,971	317,494	360,473	363,173	373,574	409,306	1.9	20
Indonesia	18,193	84,154	99,729	104,825	107,121	108,783	0.5	12
Malaysia	23,433	49,727	53,747	58,264	61,225	63,154	0.3	19
Thailand	21,651	60,688	66,207	71,272	77,500	78,386	0.4	21
Philippines	19,390	50,352	57,119	64,575	71,767	74,702	0.3	26

Source : US Science and Engineering Indicators 2016

8.7.2 Value Added of HT Industries in Selected Countries

A notable trend from 2000 to 2014 has been the increase in the value added for HT products in most of the countries (Table 8.9). The United States continues to display the most vigorous value added for HT products compared to other economies such as China and the European Union over the years. Between 2000 and 2014, the HT value added for Latin America, South and East Asia and Southeast Asian economies – such as Brazil, India, South Korea, Taiwan, Malaysia, Singapore, and Indonesia – rose significantly. Again, the United States (28.7%) remained the top contributor to the world’s value added for HT products, followed by China (27.3%) and the European Union (17%). Malaysia (0.8%) leads in the top spot among Southeast Asian economies except for Singapore. Taiwan (12.92%) and Singapore (10.62%) contributed the most share from HT products to the nation’s GDP. This is in contrast to India (0.7%) and China (4.69%), even though both of these economies had similarities in terms of a large domestic market advantage.

Table 8.9 Value Added of HT Industries in Selected Countries, 2000 – 2014

Country	HT Value-Added (USD Million)						% of World	% of GDP
	2000	2010	2011	2012	2013	2014	2014	2014
World	944,051	1,511,876	1,616,412	1,648,814	1,705,647	1,781,343	-	2.29
United States	356,389	474,396	473,199	477,424	495,919	511,004	28.7	2.93
EU	186,881	273,113	289,914	277,069	290,919	303,039	17.0	1.64
China	37,685	274,866	340,455	386,463	442,468	486,269	27.3	4.69
Japan	185,145	138,105	134,847	131,843	96,585	91,100	5.1	1.98
South Korea	31,861	66,754	61,941	56,584	54,281	55,131	3.1	3.91
Taiwan	29,784	57,378	62,013	64,430	65,844	68,477	3.8	12.92
Brazil	12,835	26,827	29,666	30,819	30,858	30,416	1.7	1.30
Singapore	13,141	29,547	31,344	32,155	31,656	32,693	1.8	10.62
India	3,285	14,319	16,209	15,136	14,506	14,529	0.8	0.70
Indonesia	2,760	9,361	10,144	10,494	10,471	10,235	0.6	1.15
Malaysia	8,964	11,395	10,858	12,006	13,198	13,896	0.8	4.25
Thailand	1,972	5,280	4,478	3,490	3,219	3,152	0.2	0.84
Philippines	4,366	3,977	4,250	4,710	5,610	5,791	0.3	2.03

Source : US Science and Engineering Indicators 2016

8.7.3 Exports of HT Industries in Selected Countries

Table 8.10 shows the exports of HT products for the period of 2004 – 2014. Generally, the HT products export value in most of the countries was expanding over the period. Within the ASEAN region, Singapore has the highest share of world exports (4.5%), followed by Malaysia (3.3%), Thailand (2.5%), the Philippines (1.2%) and Indonesia (0.5%). Malaysia's exports of HT products rose from USD64,113 million in 2000 to USD81,648 million in 2014. The highest percentage of GDP (share of exports to GDP) in 2014 among the ASEAN countries was Singapore (35.55%), followed by Malaysia (24.97%). The HT products share of GDP declined significantly for ASEAN countries from 2004 to 2014. Surprisingly, China (24%) takes the lead in share of world exports of HT products, ahead of even developed nations like the European Union (18.3%) and the United States (12.4%) in 2014.

Table 8.10 Global Key Exporters of HT Products, 2004 – 2014

Country/ Region	Exports of HT Products (USD Million)						Share of World (%)	% of GDP	
	2004	2010	2011	2012	2013	2014		2014	2004
World	1,367,045	2,084,597	2,246,237	2,307,764	2,335,738	2,441,589	-	3.15	3.14
United States	184,831	251,865	260,878	280,115	288,540	301,851	12.4	1.39	1.73
EU	7,454	361,046	405,223	410,965	437,050	446,441	18.3	1.89	2.42
China	6,426	488,927	539,340	545,242	550,668	587,068	24.0	11.93	5.67
Japan	170,951	153,165	156,102	150,980	134,995	139,514	5.7	3.43	3.03
South Korea	16,738	133,701	132,499	131,805	131,764	136,279	5.6	12.55	9.66
Taiwan	597	168,242	177,575	191,367	196,895	210,362	8.6	31.58	39.69
Brazil	7,431	9,182	8,998	9,250	10,038	10,655	0.4	1.11	0.45
Singapore	73,446	108,923	117,356	117,722	107,787	109,455	4.5	64.32	35.55
India	4,644	17,418	22,752	23,259	25,016	28,326	1.2	0.64	1.37
Indonesia	9,407	11,297	11,099	10,619	10,535	11,097	0.5	3.66	1.25
Malaysia	159,644	83,796	84,993	80,299	78,927	81,648	3.3	56.44	24.97
Thailand	33,360	58,759	57,164	56,319	59,527	61,275	2.5	20.68	16.39
Philippines	32,902	32,488	27,471	28,644	28,724	29,753	1.2	36.01	10.45

Source : US Science and Engineering Indicators 2016

8.7.4 Global Key Exporters of KI Services

A notable trend from 2004 to 2013 has been the increase in the export value for commercial KI services in most of the countries (Table 8.11). Among the ASEAN countries, Singapore is the largest exporter of commercial KI services with USD50,399 million, followed by the Philippines (USD15,233 million) and Malaysia (USD12,312 million). Besides that, Singapore had the highest share of world exports (3.25%) and share of GDP (16.67%) in 2013, while Malaysia had the lowest share of world exports (0.79%) and GDP (3.93%) – lower than even the Philippines. It is noteworthy that developed countries such as the European Union and the United States contribute greatly to the world exports share of commercial KI services, representing 31.11% and 17.46% respectively in 2013.

Table 8.11 Global Key Exporters of KI Services, 2004 – 2013

Country/ Region	Exports (USD Million)					Share of World (%)	% of GDP	
	2004	2010	2011	2012	2013		2013	2004
World	618,008	1,222,770	1,386,035	1,452,329	1,550,712	-	1.42	2.04
United States	118,948	224,219	245,762	258,448	270,755	17.46	0.97	1.61
EU	207,429	388,544	443,740	450,746	482,406	31.11	1.51	2.69
China	24,983	65,738	76,045	88,085	103,776	6.69	1.29	1.09
Japan	28,851	49,133	53,093	44,091	49,257	3.18	0.62	1.00
South Korea	9,818	21,153	23,626	30,434	36,174	2.33	1.28	2.77
Taiwan	15,706	20,705	23,560	25,550	27,024	1.74	4.51	5.28
Brazil	5,762	18,945	23,398	25,477	24,650	1.59	0.86	1.03
Singapore	24,371	35,293	41,471	46,628	50,399	3.25	21.34	16.67
India	26,774	82,671	94,869	104,278	110,708	7.14	3.71	5.95
Malaysia	3,435	7,429	9,639	11,344	12,312	0.79	2.75	3.93
Philippines	936	13,439	14,003	14,466	15,233	0.98	1.02	5.60

Source : US Science and Engineering Indicators 2016

8.7.5 Global Key Importers of HT Products

Table 8.12 shows the HT imports for selected countries. Malaysia's HT imports increased from USD52,724 million in 2013 to USD54,096 million in 2014. In 2014, China dominated globally in terms of share of HT imports (18.7%), leaving the European Union (17.5%) and the United States (14%) as the other two important importers. Singapore has the highest share (4.1%) among ASEAN countries, followed by Thailand (2.7%), Malaysia (2.2%) and the Philippines (1.0%). The import rate of HT products over GDP declined in most of the countries between 2004 and 2014.

8.7.6 Global Key Importers of KI Services

The United States and the European Union retain the lead in the imports of commercial KI services over the years (Table 8.13). Similarly, Singapore ranked top in imports among the ASEAN countries. Malaysia's import share over GDP for commercial KI services is relatively low compared to other ASEAN countries such as Singapore and the Philippines in 2004 and 2013.

Table 8.12 Global Key Importers of HT Products, 2004 – 2014

Country/ Region	Imports of HT Products, (USD Million)						Share of World (%)	% of GDP	
	2004	2010	2011	2012	2013	2014		2014	2004
World	1,367,045	2,084,597	2,246,237	2,307,764	2,335,738	2,441,589	-	3.15	3.14
United States	308,442	305,934	326,514	331,824	333,645	342,903	14.0	2.14	1.97
EU	22,555	416,812	435,161	416,294	408,136	427,996	17.5	2.11	2.32
China	22,875	367,155	393,190	421,794	436,109	457,742	18.7	9.43	4.42
Japan	263,012	118,286	127,818	140,061	135,638	148,030	6.1	1.97	3.22
South Korea	38,618	71,281	77,293	77,965	77,082	82,913	3.4	6.75	5.88
Taiwan	3,702	33,749	36,834	40,894	40,584	40,405	1.7	6.34	7.62
Brazil	14,579	38,850	42,648	44,526	45,120	47,670	2.0	2.18	2.03
Singapore	69,177	93,286	94,556	97,736	96,388	101,145	4.1	60.58	32.85
India	13,035	34,612	38,580	37,465	39,726	41,587	1.7	1.81	2.01
Indonesia	4,999	17,394	18,376	20,429	20,567	20,918	0.9	1.95	2.35
Malaysia	91,619	50,963	52,126	52,976	52,724	54,096	2.2	32.03	16.55
Thailand	50,671	59,674	63,234	63,567	64,815	67,125	2.7	31.41	17.96
Philippines	21,078	21,712	18,789	21,882	22,221	23,599	1.0	23.07	8.29

Source : US Science and Engineering Indicators 2016

Table 8.13 Global Key Importers of KI Services, 2004 – 2013

Country/Region	Imports of Commercial KI Services (USD Million)					% of GDP	
	2004	2010	2011	2012	2013	2004	2013
United States	86,409	178,123	190,688	191,243	196,370	0.20	0.26
EU	141,042	243,260	275,333	274,686	288,910	1.15	1.72
China	21,897	55,555	65,139	70,370	80,830	0.16	0.45
Japan	33,499	53,707	61,232	62,836	66,957	1.73	0.71
South Korea	14,543	34,105	38,358	41,077	40,843	0.31	0.83
Taiwan	11,084	12,466	14,683	15,685	14,308	1.45	1.10
Brazil	7,182	27,887	33,127	36,613	37,712	2.06	7.37
Singapore	14,068	30,773	34,659	37,770	39,895	2.10	1.67
India	15,743	40,986	42,884	44,702	43,205	13.79	14.29
Malaysia	4,663	9,108	10,952	12,398	13,867	0.65	0.74
Philippines	1,063	2,245	2,432	3,001	3,705	0.85	1.18

Source : US Science and Engineering Indicators 2016

8.7.7 Global Trade Balance of HT Products

Malaysia recorded a consistent HT trade surplus from 2000 to 2014 (Table 8.14). In contrast, a trade deficit is recorded for Thailand and Indonesia between 2010 and 2014. Likewise, a trade deficit pattern can be seen in the United States, Brazil and India over the period. However, the trade surplus in Singapore (since 2012) and the Philippines (since 2011) has declined. Malaysia is performing better in terms of HT trade balance compared to other ASEAN countries.

Table 8.14 Trade Balance of HT Products in Selected Countries, 2000 - 2014

Country/Region	Trade Balance (USD Million)					
	2000	2010	2011	2012	2013	2014
United States	-50,527	-54,069	-65,636	-51,709	-45,105	-41,052
EU	-35,133	-55,766	-29,938	-5,329	28,914	18,445
China	2,334	121,772	146,150	123,448	114,559	129,326
Japan	77,640	34,879	28,284	10,919	-643	-8,516
South Korea	24,751	62,420	55,206	53,840	54,682	53,366
Taiwan	57,284	134,493	140,741	150,473	156,311	169,957
Brazil	-7,813	-29,668	-33,650	-35,276	-35,082	-37,015
Singapore	4,485	15,637	22,800	19,986	11,399	8,310
India	-3,933	-17,194	-15,828	-14,206	-14,710	-13,261
Indonesia	4,836	-6,097	-7,277	-9,810	-10,032	-9,821
Malaysia	28,844	32,833	32,867	27,323	26,203	27,552
Thailand	-23,471	-915	-6,070	-7,248	-5,288	-5,850
Philippines	10,728	10,776	8,682	6,762	6,503	6,154

Source : US Science and Engineering Indicators 2016

8.7.8 Global Trade Balance of Commercial KI Services

Malaysia registered a consistent trade deficit for commercial KI services from 2004 to 2013 (Table 8.15). Similarly, Japan, South Korea and Brazil experienced a significant trade deficit over the years. Among the ASEAN countries, Singapore and the Philippines (except 2004) recorded a greater trade surplus between 2004 and 2013. Likewise, other developed nations such as the European Union, the United States and Taiwan documented larger trade surpluses. While Malaysia is performing well in HT manufacturing trade, its trade balance in KI services is less impressive.

Table 8.15 Global Trade Balance, Commercial KI Services, 2004 – 2013

Country/Region	Trade Balance (USD Million)				
	2004	2010	2011	2012	2013
United States	32,539	46,096	55,074	67,205	74,385
EU	66,387	145,284	168,407	176,060	193,496
China	3,086	10,183	10,906	17,715	22,946
Japan	-4,648	-4,574	-8,139	-18,745	-17,700
South Korea	-4,725	-12,952	-14,732	-10,643	-4,669
Taiwan	4,622	8,239	8,877	9,865	12,716
Brazil	-1,420	-8,942	-9,729	-11,136	-13,062
Singapore	10,303	4,520	6,812	8,858	10,504
India	11,031	41,685	51,985	59,576	67,503
Malaysia	-1,228	-1,679	-1,313	-1,054	-1,555
Philippines	-127	11,194	11,571	11,465	11,528

Source : US Science and Engineering Indicators 2016

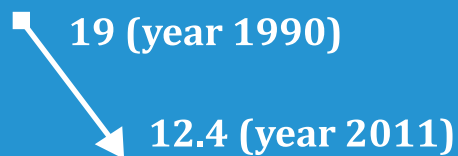
8.8 Summary

KTI industries - both HT and KI - are playing a crucial role in enhancing the national economy in Malaysia. Nevertheless, Malaysia's KTI value added is lower (USD63,154 million; GDP share of 19%) in contrast to other Asian economies such as the Philippines, Thailand and Singapore. The KI sector's value added in Malaysia recorded an increase from USD11,782 million to USD38,154 million between 2000 to 2014. The financial and business services are the among top KI services which registered the highest value added output. Health and social services, education services and business services recorded a significant value added growth of 37.4%, 32.2% and 23.7% respectively between 2010 and 2014. Whereas, in HT industries, the semiconductor as well as computer and office machinery industries contributed the highest in terms of value added and exports. The testing, measuring, and control instruments, pharmaceutical and aircraft and spacecraft sectors recorded an impressive export growth correspondingly over the period. These industries can be new potential growth industries in Malaysia. Comparatively, in 2014, Malaysia's KI industry value added output was lacking behind compared to other ASEAN nations like Indonesia, the Philippines, Thailand and Singapore. Ultimately, Malaysia is losing its long-term competitiveness to other ASEAN countries, mainly in the KI services segment. It is noteworthy that from 2004 to 2013, Malaysia is documented to have a consistent trade deficit in commercial knowledge intensive services compared to other ASEAN nations like Singapore and the Philippines.



Energy and Green Technology

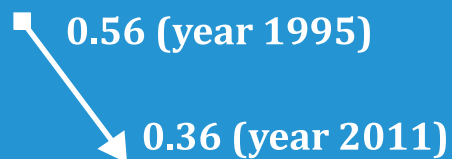
GHG emission declined drastically



Electricity of RE produced in 2014

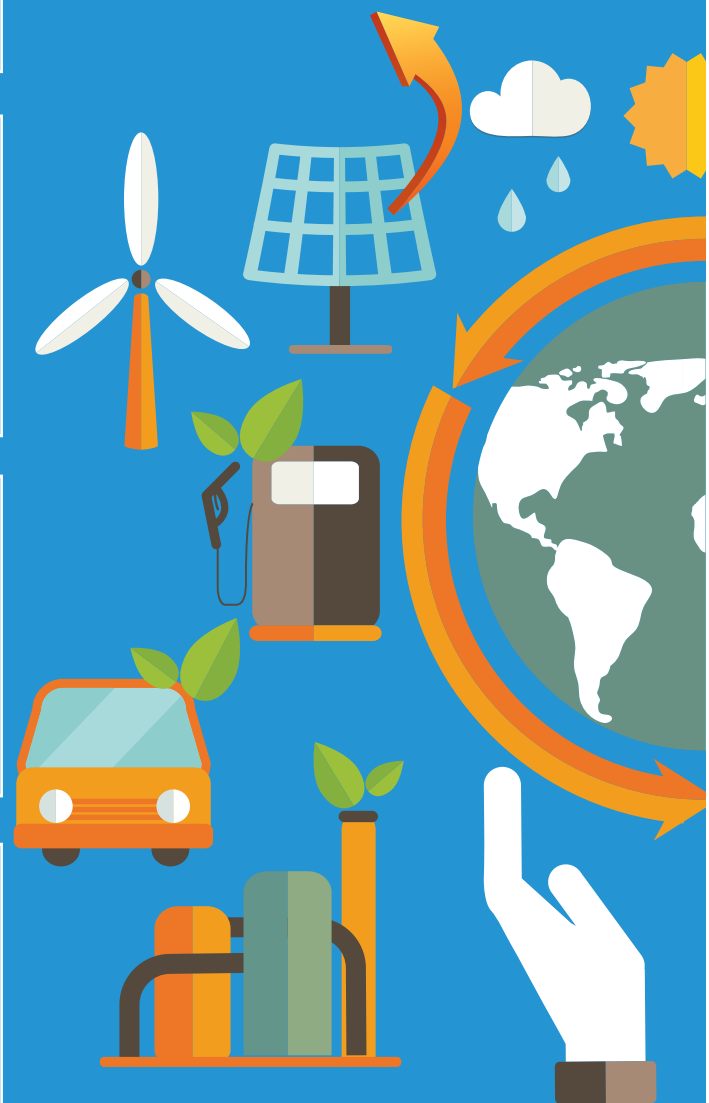
878,377 MWh

CO₂ intensity



Electricity Generation & Installed Capacity of RE by public and private licensees - 2014)

894.4MW
(878,377 MWh)



▶▶ CHAPTER 9

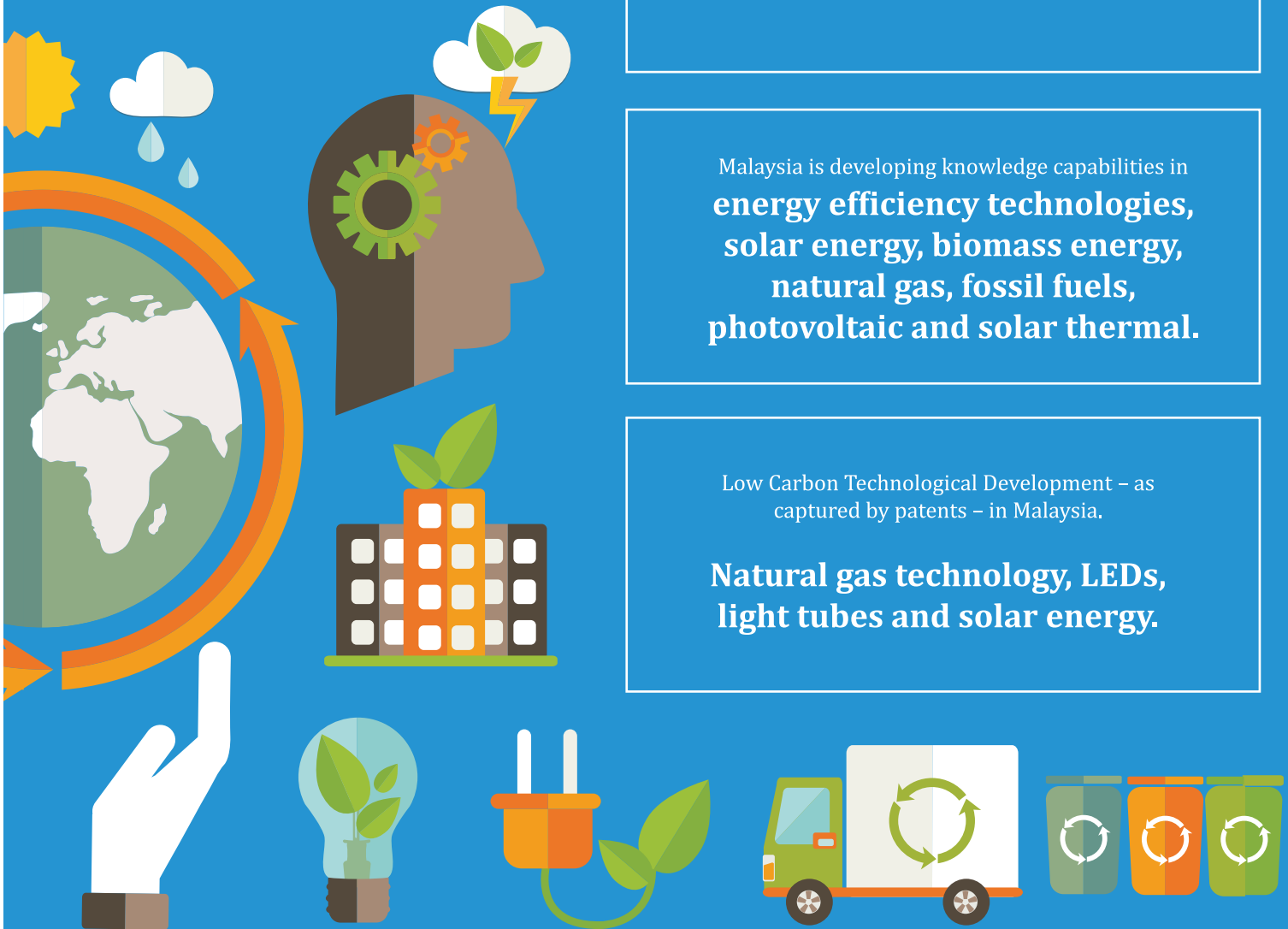
Solar PV industry sales contribution in 2013

RM12 billion

Malaysia is developing knowledge capabilities in **energy efficiency technologies, solar energy, biomass energy, natural gas, fossil fuels, photovoltaic and solar thermal.**

Low Carbon Technological Development – as captured by patents – in Malaysia.

Natural gas technology, LEDs, light tubes and solar energy.



CHAPTER 9: ENERGY AND GREEN TECHNOLOGY

9.1 Introduction

The progress in renewable energy (RE) and green technology is much anticipated. Given the global move to cleaner technologies – as well as attempts to reduce greenhouse gas emissions in order to lessen climate change – understanding Malaysia's position in these new technologies is important. Indeed, at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties – 15 (COP-15) in Copenhagen, Malaysia committed to reduce its carbon footprint by 40% compared to 2005 levels by 2020. Subsequently, in 2015 Malaysia submitted its Intended Nationally Determined Contribution (INDC) that requires significant progress in green or low carbon technology. Malaysia has committed to green growth initiatives in various ways. Various policies and institutions were established, and among the important policies in place are the National Green Technology Policy, National Renewable Energy Policy and National Policy on Climate Change. Likewise, in June 2011 the Renewable Energy Act was launched to establish and implement the Feed-in Tariff (FiT) system in order to accelerate the RE mix. In supporting the green initiatives, institutions such as the Sustainable Energy Development Authority Malaysia (SEDA) and Malaysian Green Technology Corporation – to name a few – have been formed to champion the green agenda of the government.

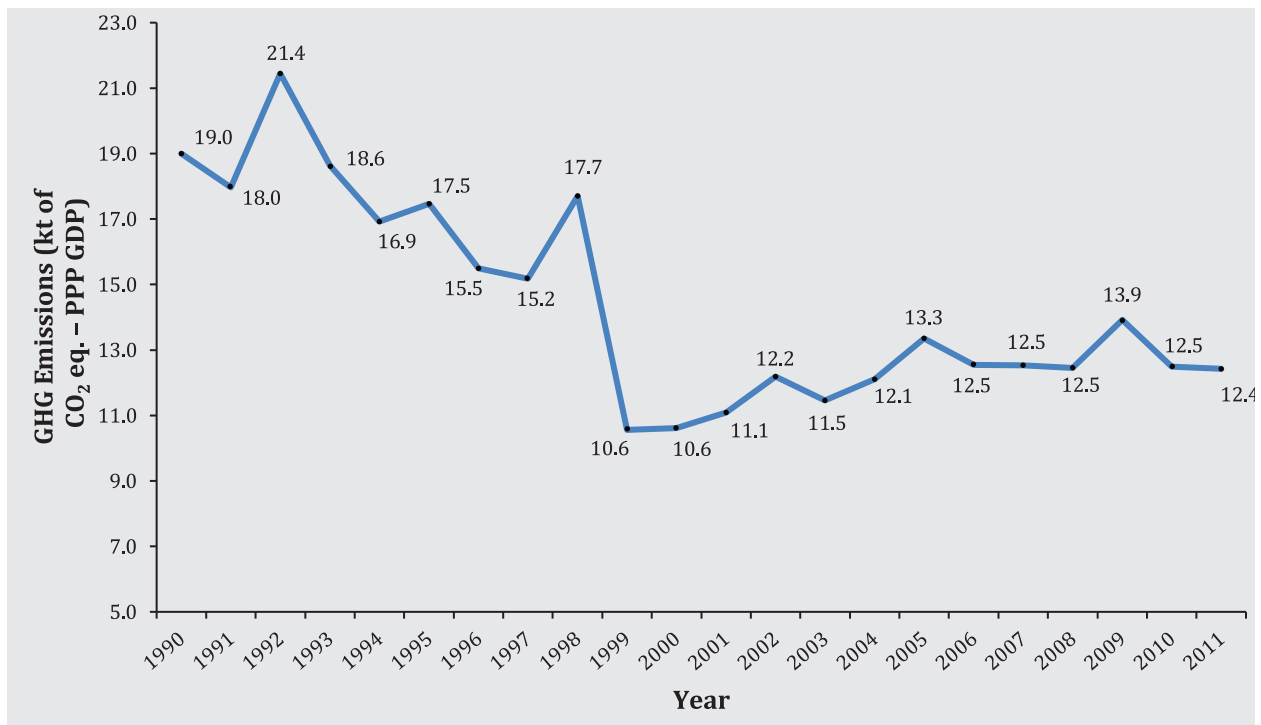
This chapter reports and assesses Malaysia's progress in green growth using some of the selected green growth indicators. These indicators follow the proposed green growth framework and indicators by OECD²¹ (OECD, 2013). This chapter uses some of these indicators selectively and also reports other relevant STI indicators related to green growth and technology.

9.2 Energy and Environment

Sustainable development is key for the future progress of Malaysia. This was well emphasised in the 11th Malaysia Plan that targets balanced development. It requires efforts to decouple emissions and energy use intensity from economic growth. Indeed, moving towards alternative energy sources and more clean energy use is desirable to promote sustainable development in Malaysia. Figure 9.1 and Figure 9.2 show the greenhouse gas (GHG) emission and carbon dioxide (CO₂) emission intensity of Malaysia respectively. GHG emissions intensity declined drastically from 19 in 1990 to 10.6 in 2000, and stabilised in a range of 10 to 14 in the period of 2000 – 2011. As for CO₂, a similar trend is observed where the intensity decreases from 0.56 in 1995 to 0.36 in 2011. This is far below the world's average CO₂ intensity of 0.50. Various initiatives could have contributed to the decrease. Indeed, Malaysia was able to reduce CO₂ emissions by 33% in the five years since 2010. This may indicate that Malaysia has been moving towards decoupling emissions from economic growth.

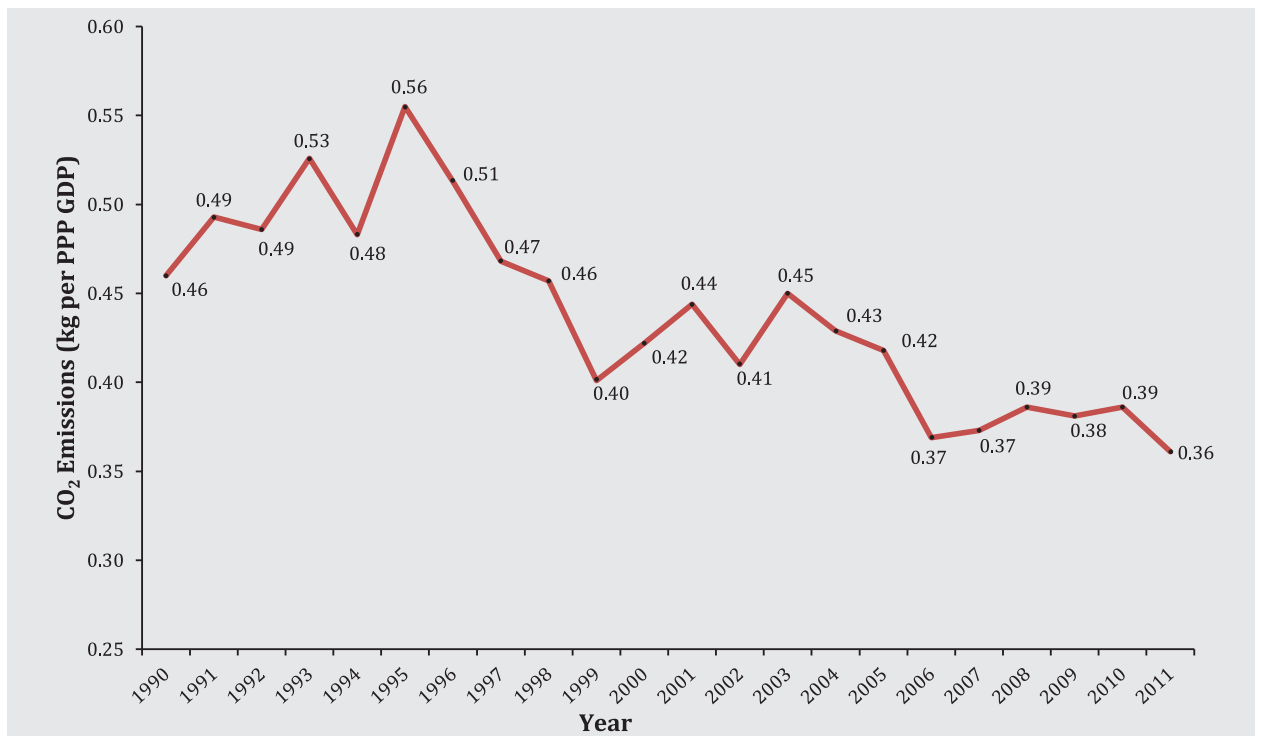
²¹ The common efforts towards establishing Green Growth Indicators is the joint work of the Global Green Growth Institute, the OECD, the United Nations Environment Programme and the World Bank.

Figure 9.1 Greenhouse Gas Emissions Intensity, 1990 – 2011



Note : 2011 constant price. PPP refers to Purchasing Power Parity.
 Source : World Development Indicators

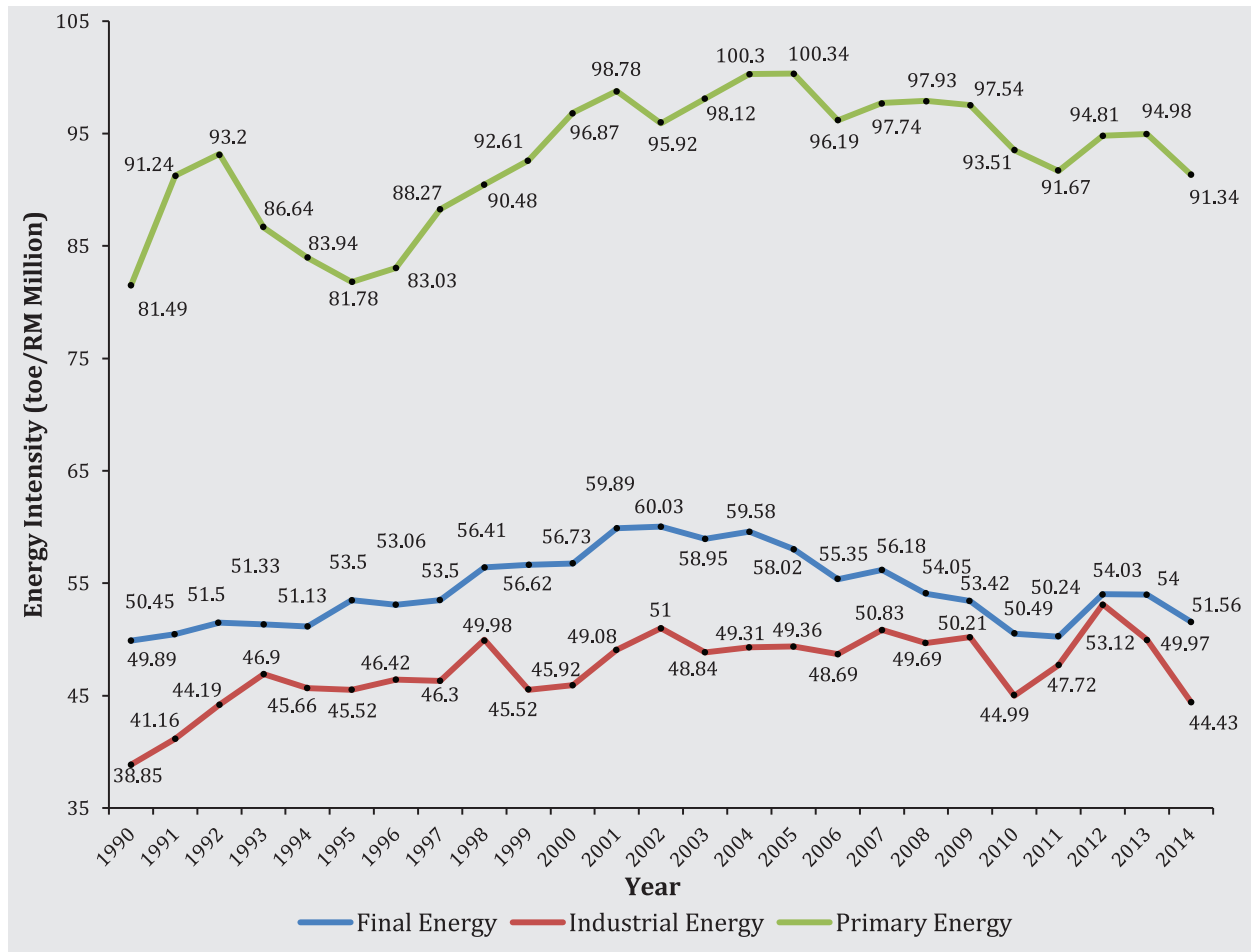
Figure 9.2 CO₂ Emissions Intensity, 1990 – 2011



Note : 2011 constant price. PPP refers to Purchasing Power Parity.
 Source : World Development Indicators

Energy intensity is a measure of the energy efficiency of a nation’s economy. It is calculated as units of energy per unit of GDP. High energy intensity indicates a high price or cost of converting energy into GDP. In terms of energy intensity, primary, final and industrial energy intensity has increased in Malaysia since 1980. Nevertheless, starting from 2005 energy intensity has started to decline, albeit slowly (Figure 9.3). Demand side management of energy consumption is crucial to further improvement of energy efficiency.

Figure 9.3 Primary, Final and Industrial Energy Consumption Intensity, 1990 - 2014



Note : Primary energy consists of total energy demand including demand from energy sectors and distribution losses, while final energy demand reflects the final user’s consumption. Based on 2010 constant price.

Source : Energy Commission

9.3 Renewable Energy

The government is increasingly promoting the adoption and use of more efficient technology in achieving more sustainable energy generation. As such, RE has become part of the energy supply mix strategy. The targeted RE generation is 985 MW or 5.5% by 2015, increasing to 11% by 2020 (2,080 MW). To achieve this, the FiT mechanism has been introduced as one measure to provide premium rates for the generation of RE. Malaysia is already home to many renowned solar players such as First Solar and AUO-Sunpower. The presence of MNCs has created the needed impetus for the creation of a solar cluster, with the development of various products within the cluster. Table 9.1 shows the current achievements of the RE mix sources. As for energy supply, RE (biodiesel, biomass, biogas and solar) contributed nearly 0.58% towards total energy supply in 2013. Energy demand met by renewables in 2015 was 0.25% of total energy demand (Table 9.1). More effort is needed to increase the RE mix which requires financial facilities, technological know-how and subsidy realisation. RE projects should be made more economically viable.

Table 9.1 Total Primary Energy Supply and Demand by Fuel Types, Mtoe

Panel A: Energy Supply (Mtoe)									
Year	Oil	Natural Gas	Coal	Hydropower	Biodiesel	Biomass	Biogas	Solar	Total
2000	20,242	26.370	2.486	1.560	-	-	-	-	50.658
2005	24,264	33.913	6.889	1.313	-	-	-	-	66.379
2010	25,008	36.936	14.777	1.577	-	-	-	-	78.298
2011	26,903	35.740	14.772	1.850	0.024	-	-	-	79.289
2012	29,502	38.648	15.882	2.150	0.115	0.183	0.004	0.011	86.495
2013	32,474	39.973	15.067	2.688	0.188	0.297	0.006	0.038	90.731
Panel B: Energy Demand (Mtoe)									
2014	35.4	36.7	15.4	3.1		0.225			90.3
2015	36.2	35.8	17.6	3.3		0.236			93.1

Source : Energy Commission, SEDA

Table 9.2 shows the electricity generation and installed capacity of RE by public and private licensees according to regions in 2014. In total, private and public licensees have 894.4 MW installed capacity of RE. In Peninsular Malaysia, Sabah and Sarawak, a total of 342,466 MWh, 129,223 MWh and 11,841 MWh of RE electricity respectively was generated by the public licensees. The private licensees generated a total of 110,137MWh (Peninsular Malaysia, 241,450 MWh (Sabah) and 43,260 MWh (Sarawak) electricity using RE in 2014. In total, public and private licensees have produced 878,377 MWh electricity of RE.

Table 9.2 Electricity Generation and Installed Capacity of RE, 2014

PUBLIC LICENSEE		
Type Of Prime Mover	Installed Capacity (MW)	Units Generated (MWh)
PENINSULAR MALAYSIA		
Mini Hydro- FiT	9.2	41,976
Mini Hydro- Independent Power Producers	20	52,880
Mini Hydro- Cameron Highlands Scheme	11.9	30,321
Mini Hydro- TNB	9.3	8,753
Solar- Non FiT	1.3	797
Solar- FiT	159.7	158,870
Biogas- FiT	11.7	43,624
Biomass- FiT	19	5,245
SUBTOTAL	242.1	342,466
SABAH		
Mini Hydro- SESB	8	19,943
Mini Hydro- FiT	6.5	16,650
Biomass- FiT	41	230
Biomass- Co-Generation	24.2	92,400
SUBTOTAL	79.7	129,223
SARAWAK		
Mini Hydro- SEB	7.3	11,540
Solar	0.3	301
SUBTOTAL	7.6	11,841
GRAND TOTAL	329.4	483,530
PRIVATE LICENSEE		
PENINSULAR MALAYSIA		
Biomass- Self-Generation	293.3	110,137
SUBTOTAL	293.3	110,137
SABAH		
Biomass- Co-Generation	93.5	63,450
Biomass- Self-Generation	118.2	178,000
SUBTOTAL	211.7	241,450
SARAWAK		
Biomass	60	43,260
SUBTOTAL	60	43,260
GRAND TOTAL	565	394,847

Note : Public licensee is a licensee that generates for own use and for supply to others, while private licensee generates for own use only. TNB, SESB and SEB refer to Tenaga Nasional Berhad, Sabah Electricity Sdn Bhd and Sarawak Energy Berhad respectively.

Source : Energy Commission, TNB, SESB, SEB and Ministry of Public Utilities Sarawak

Table 9.3 shows fuel mix in the power generation sector. In 1990, oil dominated the fuel mix as an important source of power generation, followed by natural gas. Gradually, Malaysia has moved from oil to natural gas and coal as the important sources of fuel mix. Natural gas and coal represented nearly 87% of the fuel mix in 2014. Given the price advantage and depletion of natural gas, coal will dominate the fuel mix in the future. The Five-Fuel Diversification Policy in 2000 recognised renewables as the fifth fuel mix, and in 2014 renewables represented 0.54% of the fuel mix. Nevertheless, challenges remain due to subsidisation of natural gas and higher technological cost for RE.

Table 9.3 Source of Fuel Mix in Power Stations, ktoe, 1990 – 2014

Years	Fuel Oil	Diesel	Natural Gas	Hydropower	Coal	Renewables
1990	2,873	116	1,361	915	813	-
1991	2,687	164	2,533	1,053	963	-
1992	2,352	160	3,144	997	968	-
1993	2,388	87	4,374	1,262	884	-
1994	1,957	249	5,119	1,652	925	-
1995	2,073	265	6,414	1,540	957	-
1996	2,354	284	7,489	1,243	950	-
1997	2,482	185	7,531	790	882	-
1998	2,130	275	8,886	1,113	964	-
1999	950	172	10,162	1,668	1,332	-
2000	592	191	11,580	1,612	1,495	-
2001	730	278	11,922	1,687	1,994	-
2002	1,363	476	12,424	1,329	2,556	-
2003	289	340	10,893	1,056	4,104	-
2004	274	272	10,545	1,329	5,327	-
2005	275	298	12,271	1,313	5,541	-
2006	171	617	12,524	1,567	5,964	-
2007	199	314	12,549	1,522	7,486	-
2008	181	299	13,651	1,964	8,069	-
2009	205	384	13,390	1,627	9,010	-
2010	125	415	12,628	1,577	12,951	-
2011	1,103	981	10,977	1,850	13,013	-
2012	550	811	11,533	2,150	14,138	80
2013	392	623	13,520	2,688	13,527	208
2014	269	622	13,860	3,038	13,648	171

Note : Excluding co-generation and private power plants

Source : Energy Commission

The Solar PV industry is part of the diodes, transistors and semiconductor devices (DTSD) sub-sector²². DTSD is one of the sectors of Malaysia with potential, contributing almost 6.2%

²² It belongs to MSIC 26101 (Malaysia Standard Industrial Classification).

to the total manufacturing sales value in Malaysia. In 2010, the total sales value of DTSD was RM33.2 billion (based on Annual Survey of Manufacturing Industries by DOSM). Within DTSD, the solar PV industry sales contributed RM6.4 billion which consists of about 3.47% to the total electrical and electronics (E&E) sales and 1.2% to the total manufacturing sales (Table 9.4). Given the global prospects of the industry, it expected to contribute significantly. In 2013, the sales of the solar PV industry doubled to RM12 billion.

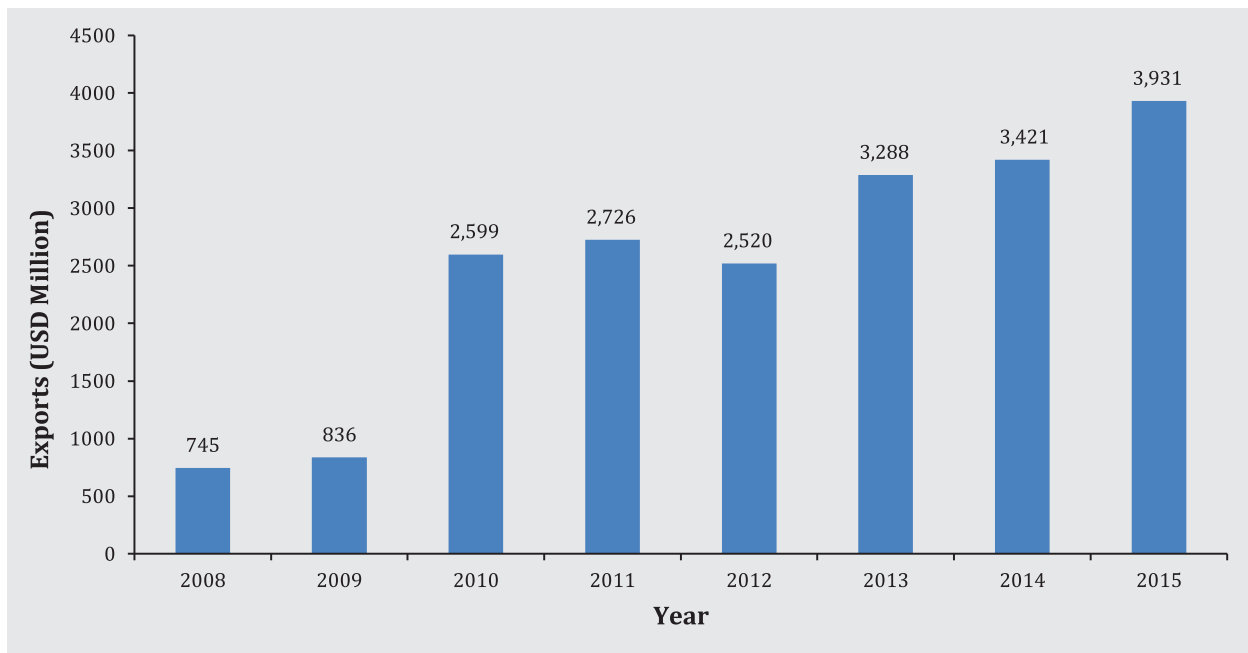
Table 9.4 Sales of Solar PV, E&E and Total Manufacturing, Malaysia, 2010 – 2013

Industry	Sales (RM Billion) 2010	%	Sales (RM Billion) 2013	%
Solar PV Industry	6.4		12	
Total E&E Industry	184.3	3.47	185	6.49
Total Manufacturing	532.7	1.20	620.6	1.93

Source : DOSM, Manufacturing Survey; MIGHT, 2016

The exports of PV products significantly improved, from USD745 million in 2008 to USD3,931 million in 2015 (Figure 9.4). Between 2008 and 2015, the annual average export growth was 38.6%, a significant increase within 8 years. A few key factors have elevated Malaysia as one of the top production hubs for solar products, namely generous tax breaks that attracted foreign direct investment as well as FiT and other government policies.

Figure 9.4 Exports of PV Products, 2008 – 2015



Note : PV products refers to HS 854140
Source : Comtrade database

9.4 Green Technology Financing

Financing has been the major barrier in the diffusion of green technology. The Green Technology Financing Scheme was established in 2010 with a total financing amount of RM1.5 billion in an effort to boost the supply and utilisation of green technology. The government supports interest subsidies of 2% from the total interest rate imposed by the financial institutions, as well as provides a government guarantee of 60% on the total approved loan. An additional RM2 billion was allocated in 2013, making the total financing RM3.5 billion. The financing ends in 2017. The projects should be located in Malaysia and should utilise local or imported technology. The financing will benefit the users or producers of green technology. For producers, the financing is up to 15 years with a maximum cap of RM50 million, while users are financed up to 10 years with a cap of RM10 million. The financing is only for new or expansion projects that incorporate green technology that is yet to be financed. As of mid-2015, approved green technology (GT) financing value amounted to RM2.236 billion (Table 9.5). The financing has been utilised up to 63.7% while the remaining amount will be allocated until the end of 2017. In total, 26 banks participated in financing green technology projects and approved nearly 185 projects. These projects have created RM4.41 billion in investment, 2,898 green jobs and 2.65 tonnes of CO₂ emission reduction.

Table 9.5 shows the financing of projects based on type. In terms of number of projects and value of financing, most of the approval of financing goes to the solar related projects. Solar farm secured 14 projects with a value of RM450.2 million, while the solar building-integrated photovoltaics (BIPV) system projects secured 69 projects with an approved investment of RM409.2 million. Biomass power plant secured RM406.9 million with 13 projects. Hydro Power Plant and Green Product Manufacturing secured RM264.8 million and RM189.5 million respectively. As for the energy efficiency projects, RM44.4 million was approved with 12 projects in an effort to improve the demand side management of energy.

Table 9.5 Project Financing by Type of Project, as of Mid 2015

Type of Projects	Green Project Certificate		Projects with Secured Financing		Financing Amount (RM)
	Number of Projects	Percentage (%)	Number of Projects	Percentage (%)	
Solar Farm (RE)	15	4	14	7.6	450,176,640.00
Solar-BIPV System (RE)	103	27.2	69	37.3	409,223,010.00
Biomass Power Plant (RE)	19	5	13	7	406,878,610.00
Hydro Power Plant (RE)	15	4	8	4.3	264,858,250.00
Green Product Manufacturer	61	16.1	23	12.4	189,512,960.00
Biogas Power Plant (RE)	29	7.7	14	7.6	135,052,600.00
Waste Recycling	41	10.8	16	8.6	128,608,106.00
Pulp	7	1.8	3	1.6	97,500,000.00
Pellet Plant	21	5.5	5	2.7	61,345,117.00
Energy Efficiency	40	10.6	12	6.5	44,441,052.00
Compost	18	4.7	4	2.2	39,451,000.00
Dry Fibre	10	2.6	4	2.2	8,670,000.00
Total	379	100	185	100	2,235,717,345.00

Source : GreenTech Malaysia

Table 9.6 shows the achievements of the FiT Scheme as of October 2015. The FiT scheme was established in 2010 to improve the RE mix in the total energy supply. The scheme was administrated through the Renewable Energy Act 2011. Not only was it instrumental in kick starting RE, but it also created new green jobs and investments in various RE technologies such as biogas, biomass, mini hydro and solar PV. Biomass and Solar PV contributed the most to job creation with 7,675 and 7,488 jobs respectively. Mini Hydro and Biogas contributed 4,100 and 3,392 employments in the respective industries. Besides, a total reduction of 2,130,805 tonnes of CO₂ was achieved with a total investment of RM 6.9 million.

Table 9.6 Achievements of FiT Scheme, as of October 2015

Renewables	No of Jobs Created	RE generation (MWh)	Installed Capacity (MW)	FiTCD Capacity (MW)	CO ₂ Reduction (tonnes)	Total Investment (RM)
Biogas (palm oil waste, agro based & farming)	3,392	949,431.10	135.69	17.23	683,066.39	1,636,042.41
Biomass (palm oil waste, agro based & farming)	7,675	1,531,516.74	257.99	74.9	1,026,072.15	2,565,596.78
Mini Hydro	4,100	1,704,289.3	273.34	18.3	1,220,830.17	1,708,680.94
Solar PV	7,488	405,653.20	299.53	215	292,526.54	706,182.27
Geothermal	450	236,520.00	30	0	129,139.92	366,139.92
Total	23,105	4,827,410.34	996.55	325.43	2,130,805.00	6,982,642.32

Note : FitCD refers to FiT Commissioning Date.

Source : SEDA

9.5 Green Scientific Knowledge and Low Carbon Technology Inventions

The progress in low carbon technologies is vital given the environmental and climate changes that the world faces. As part of the assessment, identifying the research and knowledge capabilities of Malaysia in low carbon technologies indicates the vital STI position of Malaysia in these technologies. Scientific publications and patent data are used to evaluate the research and knowledge capabilities of Malaysia. The technology focus includes research and knowledge capabilities in energy-related technologies. Table 9.7 depicts the categorisation of low carbon technologies.

Table 9.7 Technologies Classified under Low Carbon Energy Technologies

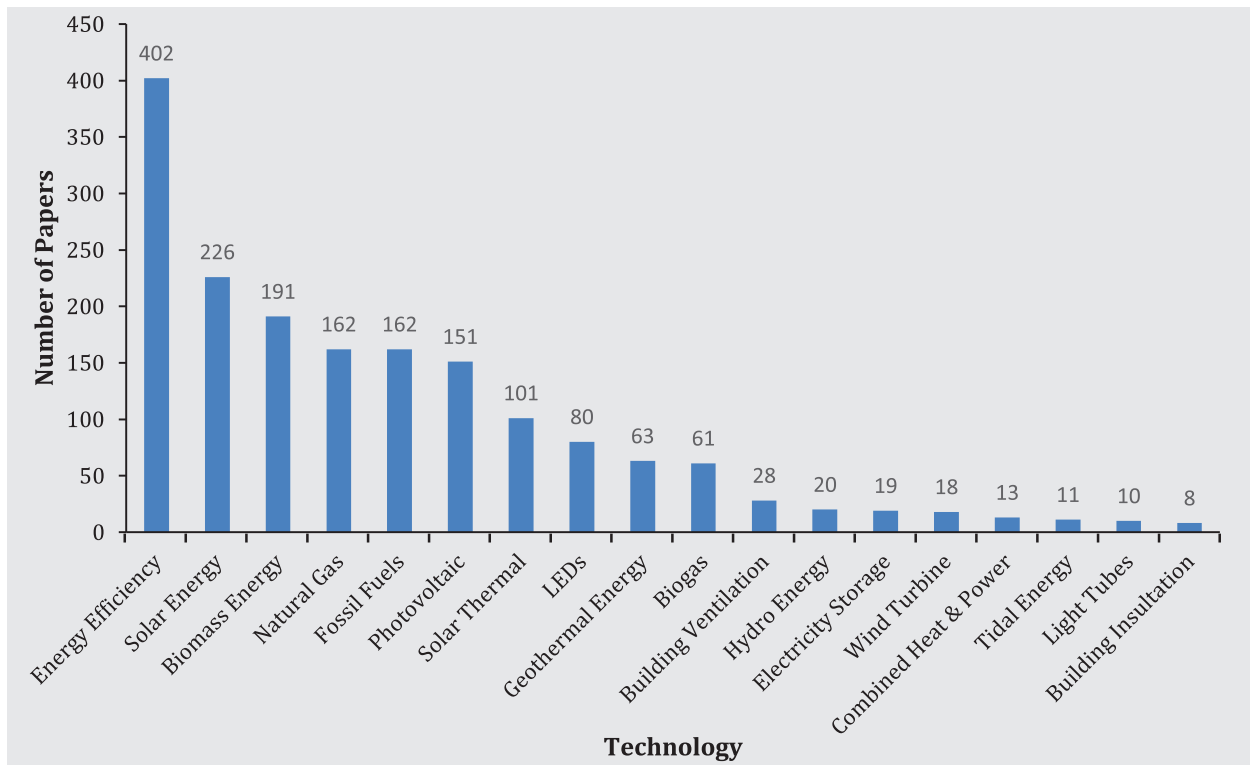
Category	Technology
Renewable	<ul style="list-style-type: none"> • Combined heat and power • Tidal energy • Wind turbine • Geothermal energy • Solar energy • Photovoltaic • Solar thermal • Biomass energy • Biogas • Energy storage • Hydro energy • Electricity storage
Fossil fuel	<ul style="list-style-type: none"> • Fossil fuels (all types) • Natural gas • Electricity storage
Energy Saving	<ul style="list-style-type: none"> • Energy efficiency • Building ventilation • Building insulation • Light tubes • LED

Source : Wong et al. (2014, p. 793)

Figure 9.5 shows the scientific knowledge of Malaysia in low carbon technologies. As a whole, Malaysia seem to be developing knowledge capabilities in energy efficiency technologies, followed by solar energy, biomass energy, natural gas, fossil fuels, photovoltaic and solar thermal. The scientific knowledge production of Malaysia is similar to that of some of the advanced countries such as Japan, South Korea, Singapore and emerging China – where their current focus is on energy efficiency technologies, light-emitting diodes (LEDs), photovoltaic and solar energy. Nevertheless, the scientific knowledge production of these countries is greater than Malaysia. This knowledge production is important to support the Malaysian government initiatives to promote green technology and reduce greenhouse gas emissions, as indicated in the intended nationally determined contribution – where Malaysia is committed to reduce GHG emissions intensity of GDP by 45% by 2030.

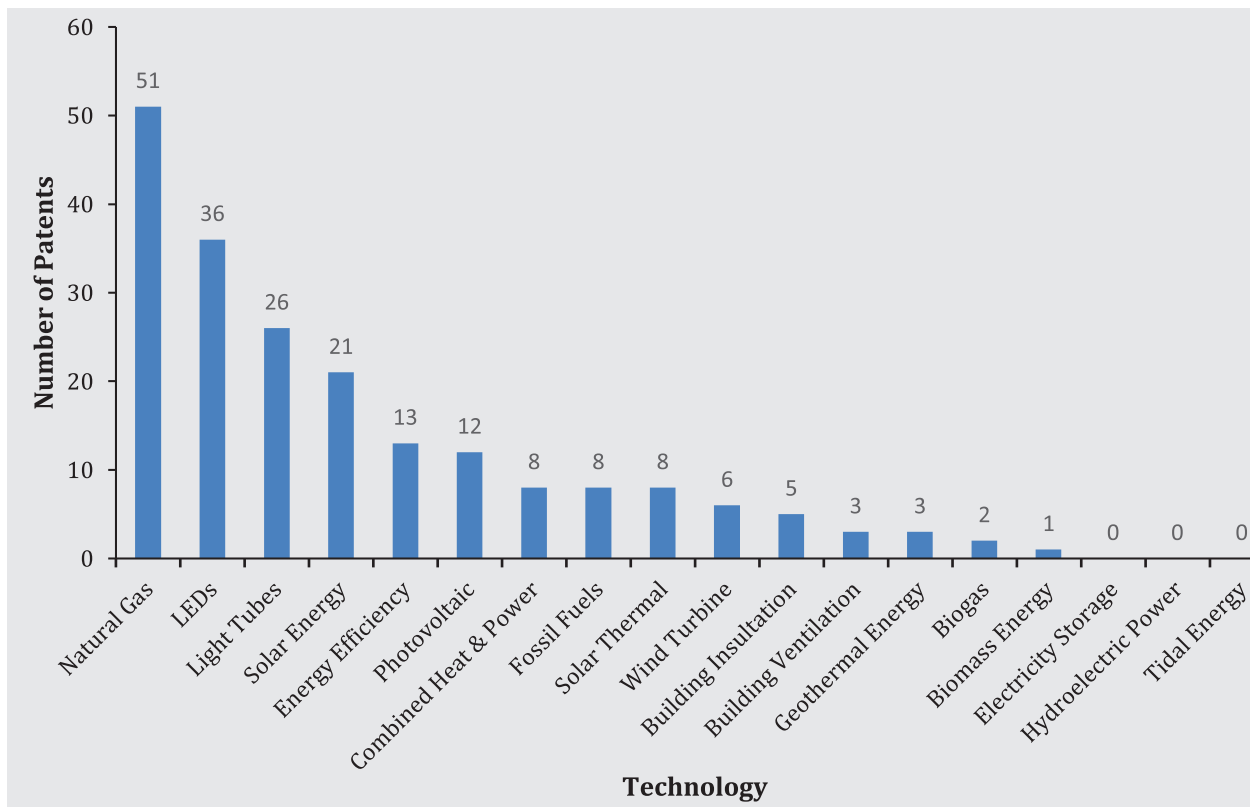
Figure 9.6 shows the technological development – as captured by patents – related to low carbon energy technology of Malaysia. Natural gas technology emerges as one of the productive fields followed by LEDs, light tubes and solar energy. Other fields include energy efficiency and photovoltaic. This is consistent with the emergence of scientific knowledge in these fields as indicated in Figure 9.5. It is observed that Japan, South Korea and Singapore have similar technological focus in LEDs, energy efficiency, light tubes and photovoltaic; however Singapore seems to have paid extra attention to wind turbine. Relatively, LEDs stands out as the most productive field among the advanced countries.

Figure 9.5 Low Carbon Energy Scientific Knowledge, Malaysia, 1980 - 2012



Note : Scientific publications in WoS
 Source : Chandran et al., 2015

Figure 9.6 Low Carbon Energy Related Patents, Malaysia, 1980 - 2012



Note : Patents filed in PCT.
 Source : Chandran et al., 2015

Table 9.8 shows the efforts of Malaysian inventors in environmental related technological collaboration with others. Generally there is an increase in international collaboration on the development of environmental technologies. Nevertheless, the rate of increase and the number of collaborations are still very limited. A total of 31 environmental related technologies were developed jointly with international collaborators in 2011. The number of collaborations in general environmental management technologies and climate change mitigation technologies are 8 and 27 respectively. Collaboration is relatively low in water-related adaptation technologies over the years. For Malaysia to move towards a greener growth path, technological collaboration should be further intensified.

Table 9.8 International Collaboration in Technology Development

Technology domain	2000	2005	2006	2007	2008	2009	2010	2011	2012
Environment-related technologies	3	12	11	18	21	27	26	31	22
General environmental management	0	0	4	5	8	14	12	8	0
Water-related adaptation technologies	0	0	0	0	0	2	1	0	0
Climate change mitigation	3	8	7	14	16	16	17	27	19

Note : International collaboration refers to the number of co-inventions (simple patent families) developed jointly by at least two inventors

Source : OECD

9.6 International Comparison

This section discusses the energy related indicators of the selected ASEAN countries. A comparison on final energy intensity in ASEAN shows that Malaysia's energy intensity is relatively lower than Indonesia, the Philippines, Myanmar, Vietnam and Thailand. Overall, final energy intensity has been decreasing over the years in ASEAN. Malaysia's energy intensity decreased from 0.289 in 1971, to 0.260 in 2013 (Table 9.9). This is primarily due to improvements in efficiency in major sectors, including adoption of alternative low carbon technologies.

Table 9.9 Final Energy Intensity in ASEAN, Mtoe/Billion USD

Country	1971	1973	1980	1990	2000	2005	2010	2012	2013
Brunei	0.024	0.021	0.025	0.051	0.066	0.066	0.133	0.184	0.109
Indonesia	0.790	0.710	0.614	0.532	0.534	0.470	0.396	0.373	0.358
Malaysia	0.289	0.236	0.226	0.244	0.262	0.266	0.240	0.241	0.260
Myanmar	3.749	3.686	2.893	2.866	1.753	1.083	0.742	0.738	0.728
Philippines	0.406	0.396	0.315	0.316	0.290	0.221	0.181	0.168	0.166
Singapore	0.097	0.098	0.089	0.099	0.083	0.106	0.087	0.086	0.099
Thailand	0.424	0.419	0.363	0.325	0.368	0.396	0.404	0.406	0.416
Vietnam	1.164	1.34	1.144	0.807	0.608	0.610	0.616	0.564	0.552

Source : Energy Commission

Final energy per capita indicates energy consumption per population in a particular country. It is important to note that despite low energy intensity (per GDP), Malaysia's final energy consumption per capita is higher than many other ASEAN countries. Indeed, there is an increasing trend of energy consumption per capita in Malaysia. In 2013, final energy consumption per capita in Malaysia was 1.821 (Table 9.10). Brunei and Singapore have the highest final energy consumption per capita.

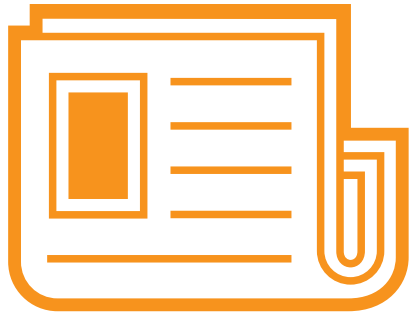
Table 9.10 Final Energy Consumption Per Capita in ASEAN

Country	1971	1973	1980	1990	2000	2005	2010	2012	2013
Brunei	1.000	1.000	1.050	1.167	1.900	1.575	3.275	4.725	2.750
Indonesia	0.274	0.277	0.342	0.446	0.58	0.600	0.621	0.647	0.648
Malaysia	0.413	0.393	0.525	0.769	1.276	1.481	1.512	1.639	1.821
Myanmar	0.258	0.245	0.242	0.223	0.237	0.259	0.249	0.274	0.286
Philippines	0.343	0.364	0.349	0.317	0.308	0.266	0.254	0.252	0.262
Singapore	0.519	0.636	0.888	1.670	2.078	3.130	3.018	3.102	3.648
Thailand	0.252	0.271	0.32	0.510	0.812	1.065	1.279	1.375	1.430
Vietnam	0.285	0.286	0.243	0.243	0.323	0.426	0.555	0.556	0.568

Source : Energy Commission

9.7 Summary

Malaysia has shown progress in green technology diffusion. With its incentives and programmes it was able to kick start the green energy mix and technological progress in low carbon technologies. Nevertheless, challenges remain in diffusing renewable technologies – given the lower cost of fossil fuels, high cost of renewable technologies, high investment needed and limited technological know-how. The planned net metering and other initiatives such as green vehicles, green buildings and others are expected to improve the STI agenda in RE of Malaysia, especially with regards to STI in green technology and research and development. More effort is needed to decouple growth from conventional sources of energy, especially switching from fossil fuels to green energy to drive the green economy.



Bibliometrics - Publication and Citations

Year 2001 - 2014
59,131 articles
118,357 authors

Total Articles in 2014

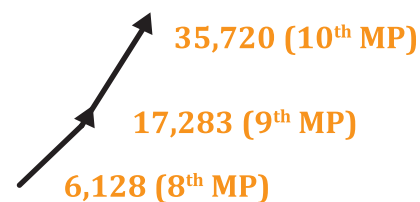
Social
Science
9%



48,737 articles
Five Research Universities
Publications (2001-2014)

The publication performance
measured by number of articles

8th - 10th Malaysia Plan



▶ Top Fields of Research in Science

- Materials Science
- Crystallography
- Engineering, Electrical & Electronics
- Engineering, Chemical
- Multidisciplinary Sciences
- Physics, Applied
- Environmental Sciences
- Food Science & Technology
- Biotechnology & Applied Microbiology

▶ Top Fields of Research in Social Science

- Economics
- Management
- Public, Environmental & Occupational Health
- Business
- Education & Educational Research

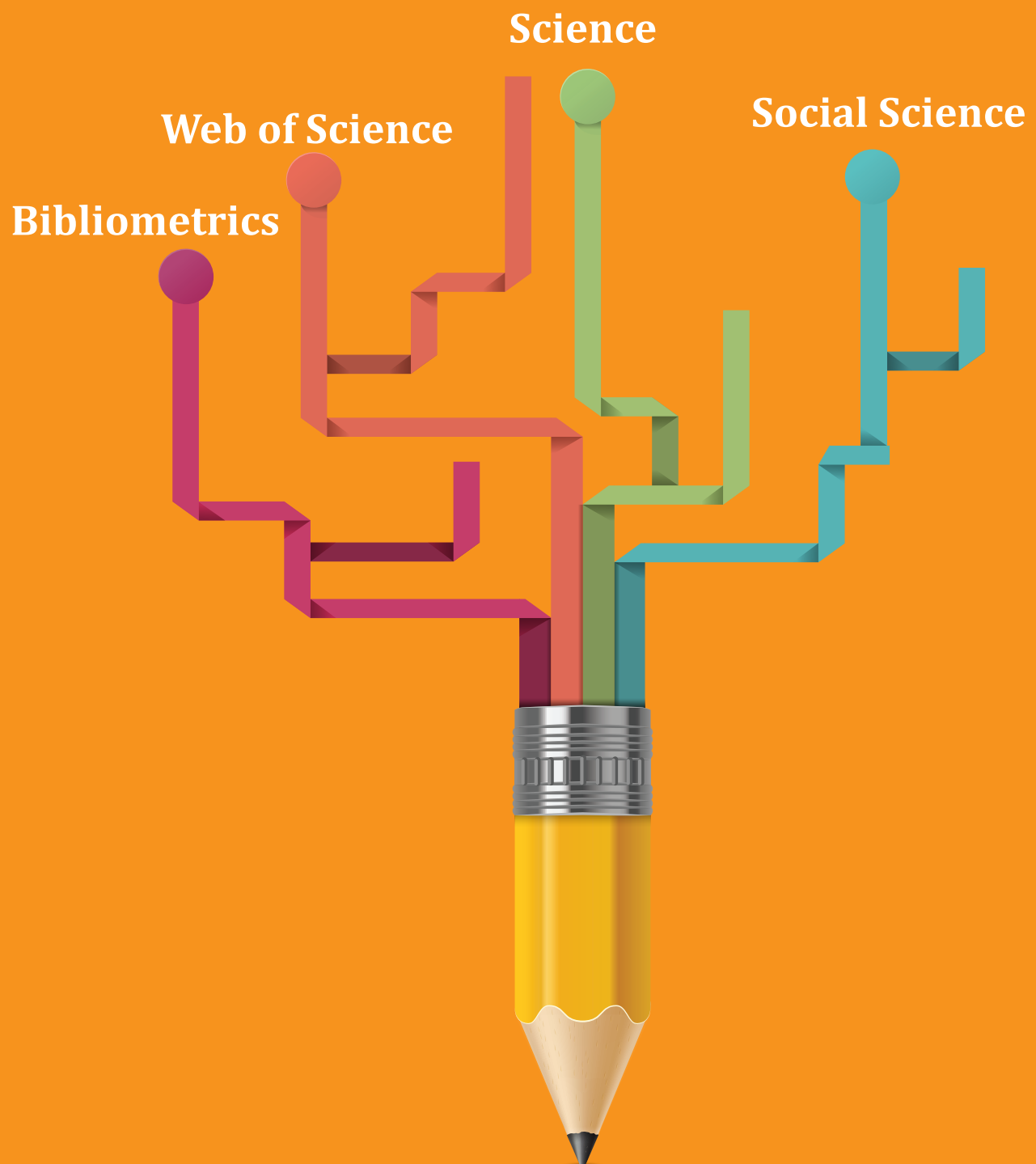
▶ Top Public Research Institutions

- Institute for Medical Research
- Malaysian Palm Oil Board
- Forest Research Institute Malaysia
- Malaysia Nuclear Agency

▶ Fields with High Citations per Article

- Environment/Ecology
- Space Science

▶▶ CHAPTER 10



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CHAPTER 10: BIBLIOMETRICS – PUBLICATION AND CITATIONS

10.1 Introduction

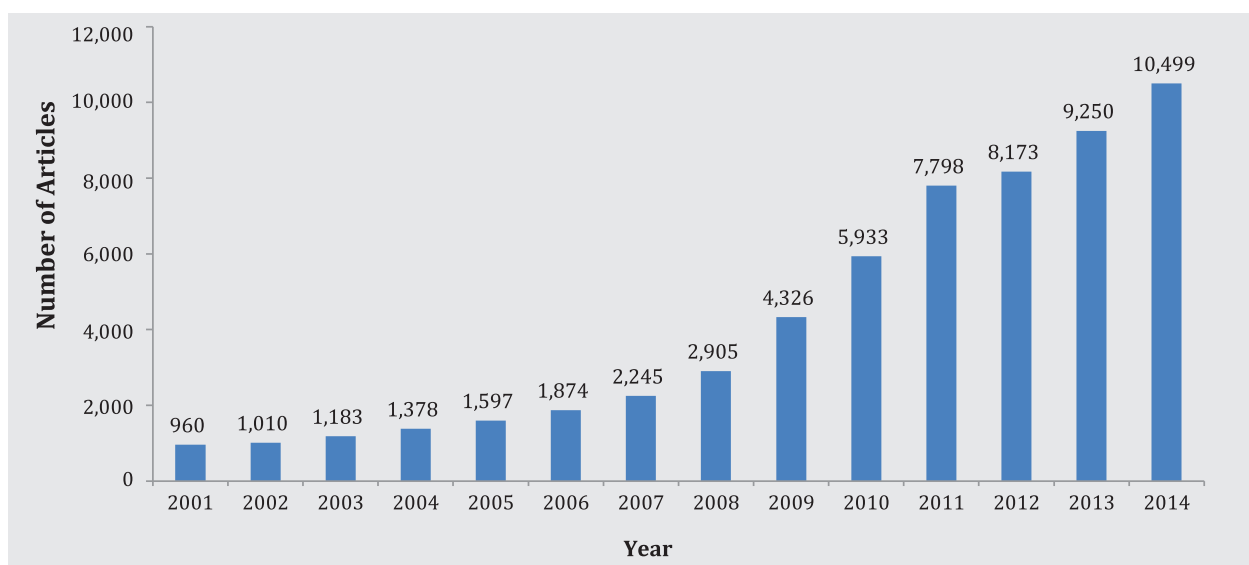
Bibliometrics is used as a tool to observe the state and progress of the scientific community of a nation through the overall production of scientific literature, at a given level of specialisation. Specifically, it aims to measure the scientific outputs. Over the past decade, this method has been used to assess the scientific performance of a country in relation to the world, an institution in relation to a country, and even individual scientists in relation to their own communities. This chapter assesses the performance of the scientific publications in Malaysia. It provides an overview of the scientific publications trend as well as its impact in terms of citations. The study details the publications in terms of published articles in journals listed in the Web of Science (WoS) and its citations, top fields of research, and top performing institutions. In addition, the chapter also reports the joint publication trends to reflect the collaboration patterns.

10.2 Performance in Scientific Publications

10.2.1 Total Publication Counts

A total of 59,131 articles from Malaysia by 118,357 authors was recorded during period of 2001 to 2014. The publication performance measured by number of articles has increased – from 6,128 in the 8th Malaysia Plan to 17,283 in the 9th Malaysia Plan and 35,720 in the 10th Malaysia Plan. Malaysia witnessed an increasing trend in publications with a drastic growth of 48.92% in 2009. Malaysia produced 10,499 articles in 2014 (Figure 10.1). This is attributed to the increasing commitment to R&D investment from public sector for scientific research and related activities. Universities played an instrumental role in the increase.

Figure 10.1 Total Number of Articles, 2001 – 2014

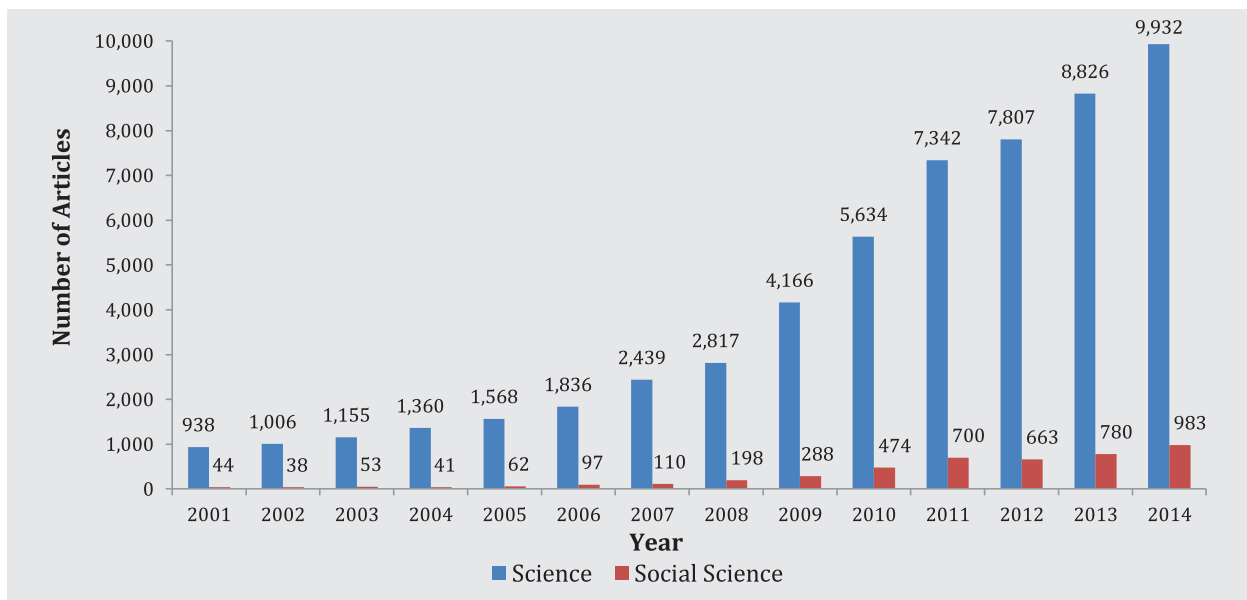


Source : Bibliometric Study 2015

10.2.2 Number of Articles between Science and Social Science

Figure 10.2 provides the articles counts for two categories, namely science and social science²³. There was a gradual increase for both categories from 2001 – 2007, and they have increased exponentially since 2007. From 2007 the average growth was 17.7% for science and 25.3% for social science. The absolute number of articles under science is much higher compared to social science. Articles under social science contribute 4%-9% of the total articles of Malaysia since 2007.

Figure 10.2 Total Number of Articles, Science and Social Science, 2001 - 2014

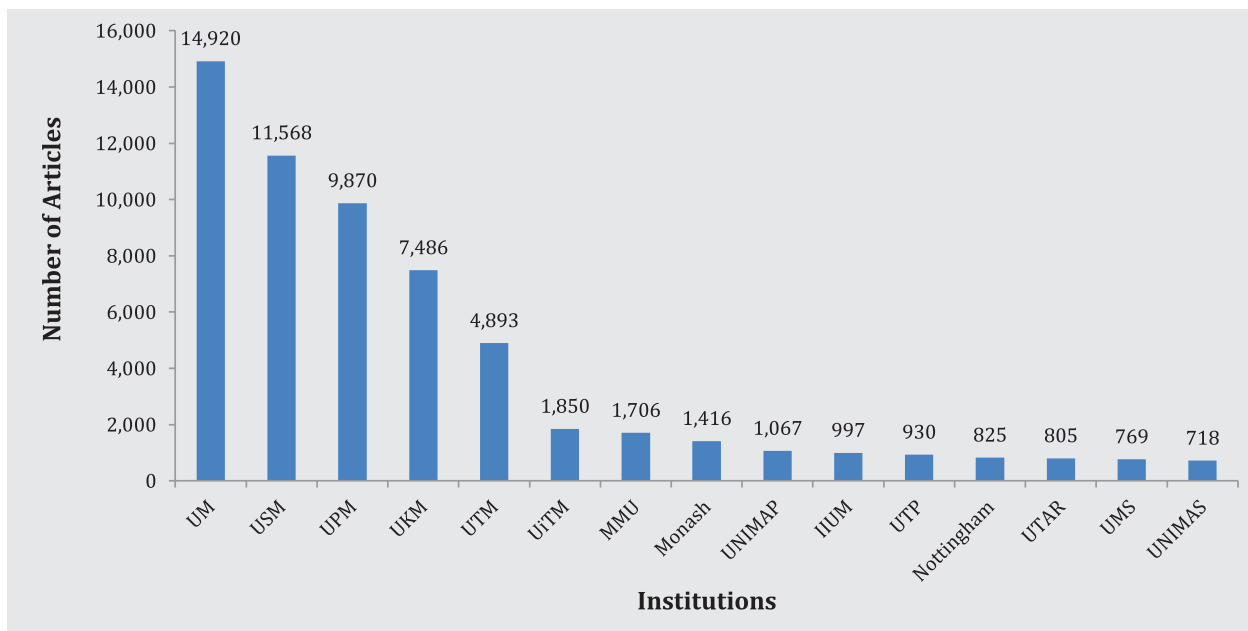


Source : Bibliometric Study 2015

10.2.3 Scientific Publications in HLIs

Figure 10.3 shows the top institutions by number of articles produced. Universiti Malaya (UM) emerged as the top institution in scientific publications, with the capacity to produce 14,920 articles over a period of 13 years (2001 – 2014). This is followed by Universiti Sains Malaysia (USM), Universiti Putra Malaysia (UPM), Universiti Kebangsaan Malaysia (UKM) and Universiti Teknologi Malaysia (UTM). These five are acknowledged as research universities (RUs) capable of producing a combined total of 48,737 articles from 2001 to 2014. The publication counts from the private universities such as Multimedia University (MMU) and Monash University (Monash) are also remarkable, with production capacities comparable to that of public universities such as Universiti Teknologi Mara (UiTM) and Universiti Malaysia Perlis (UNIMAP). The performance of MMU follows closely behind UiTM, and Monash has outperformed UNIMAP by 349 articles over a period of 13 years.

²³ There is a slight difference in terms of reported figures for the annual total count of Malaysia’s articles against those of the summation value for articles under science and social science. Note that there are articles published in journals that are classified under both science and social science categories. Therefore, some articles are listed and cited in both SCIE and SSCI. Data was extracted from the Science Citation Index Expanded (SCIE) and Social Science Citation Index (SSCI) databases respectively

Figure 10.3 Articles by Top Institutions, 2001 – 2014

Source : Bibliometric Study 2015

10.2.4 Scientific Publications in PRIs

Table 10.1 reports the number of articles produced by the Public Research Institutions (PRIs). A few research institutes are among the productive institutions. Among them are the Institute for Medical Research, Malaysian Palm Oil Board, Forest Research Institute Malaysia and Malaysian Nuclear Agency. Their performance in publications implies their active role and commitment in basic research for scientific progress in their respective fields. Other institutions such as Hospital Kuala Lumpur, Ministry of Health Malaysia, and the Malaysian Agricultural Research and Development Institute recorded above 200 article publications from 2001 – 2014.

10.2.5 Scientific Publications by Fields of Research

Table 10.2 shows the top 15 fields of research by article counts for science and social science. Materials Science with publication interest in multidisciplinary research emerged as the top field in the sciences. The performance of Materials Science is followed closely by that of Crystallography. These two fields together with Engineering, Electrical & Electronics; Engineering, Chemical; Multidisciplinary Sciences; Physics, Applied; Environmental Sciences; Food Science & Technology; and Biotechnology & Applied Microbiology are the fields that are performing at a capacity of above 2,000 articles (2001 – 2014). In social science, Economics; Management; Public, Environmental & Occupational Health; Business; and Education and Educational Research are the top performing fields, having cumulative capacity of above 300 articles across the 13 years.

Table 10.1 Articles by Public Research Institutions, 2001 – 2014

Institution	Number of Articles
Institute for Medical Research	731
Malaysian Palm Oil Board	620
Forest Research Institute Malaysia	564
Malaysian Nuclear Agency	399
Hospital Kuala Lumpur	327
Ministry of Health	314
Malaysian Agricultural Research and Development Institute	242
SIRIM Berhad	185
Forest Research Centre	154
Rubber Research Institute Malaysia	128
Malaysian Rubber Board	125
Penang Hospital	94
MIMOS Berhad	88
Selayang Hospital	79
Veterinary Research Institute	62

Source : Bibliometric Study 2015

Table 10.2 Malaysia's Top 15 Research Fields, 2001 – 2014

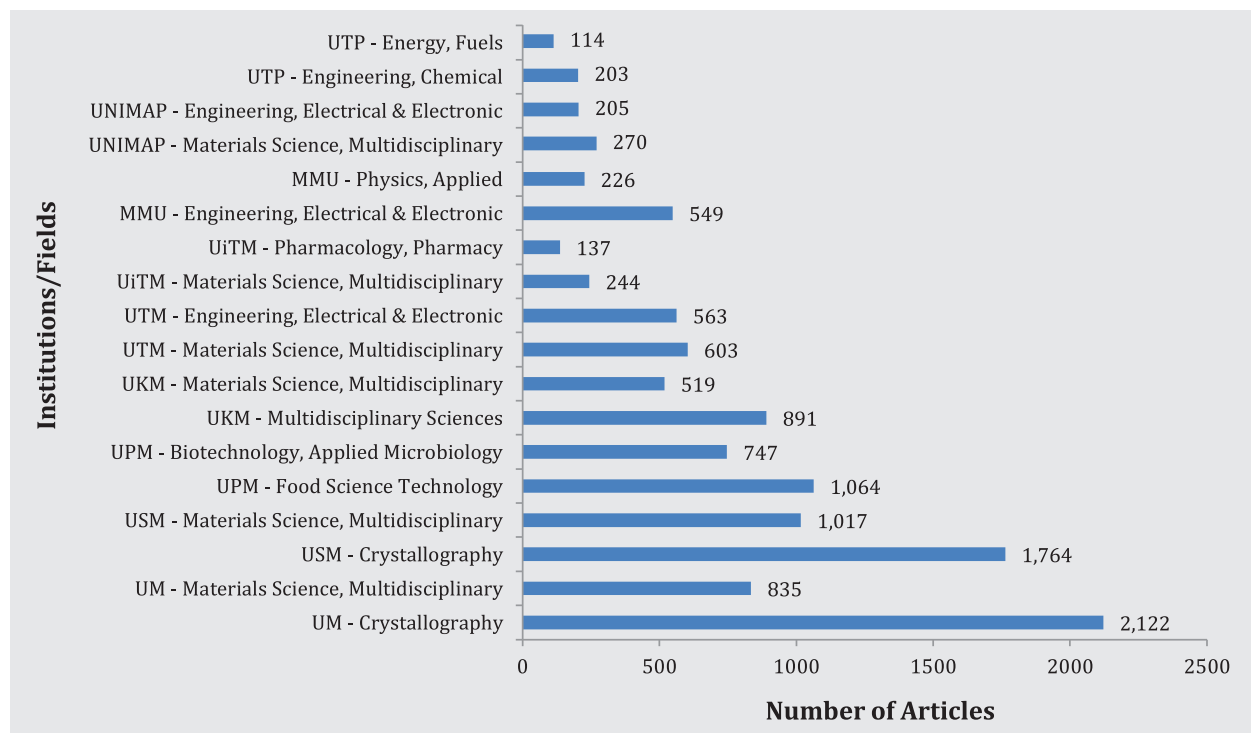
Fields	Number of Articles	%
Materials Science, Multidisciplinary	4,266	7.21
Crystallography	4,153	7.02
Engineering, Electrical & Electronics	3,346	5.66
Engineering, Chemical	2,763	4.67
Multidisciplinary Sciences	2,761	4.67
Physics, Applied	2,541	4.30
Environmental Sciences	2,258	3.82
Food Science & Technology	2,242	3.79
Biotechnology, Applied Microbiology	2,083	3.52
Chemistry, Multidisciplinary	1,899	3.21
Chemistry, Physical	1,884	3.19
Energy Fuels	1,740	2.94
Optics	1,733	2.93
Polymer Science	1,721	2.91
Pharmacology, Pharmacy	1,690	2.86

Source : Bibliometric Study 2015

10.2.6 Institutions and Fields of Research

Figure 10.4 reports the top two fields of research for selected institutions. Materials Science emerged as the desired field for research in a number of top performing institutions, including UM, USM, UKM and UTM. UM and USM shared interests in performing comparable research activities in Crystallography and Materials Science, Multidisciplinary while UPM performed in Food Science and Technology, as well as Biotechnology and Applied Microbiology. UKM stands out in Multidisciplinary Science, and UTM in Engineering, Electrical and Electronics. For social science, Economics is the desired field for a few top institutions, namely UM, UKM, UPM and Monash (see Bibliometric Study 2015). USM stands out in Management. UM, USM, UPM and Monash performed in Public, Environmental and Occupational Health, while UKM stands out in Psychiatry.

Figure 10.4 Institutions by Top Two Research Fields, 2001 – 2014



Source : Bibliometric Study 2015

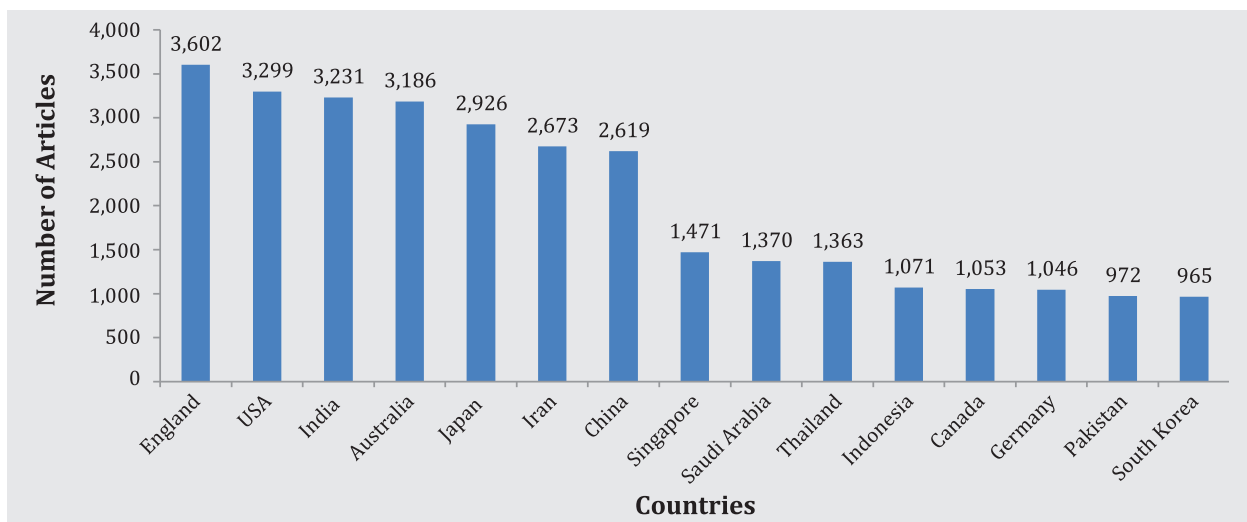
10.3 Collaboration Patterns in Publication

10.3.1 International Collaboration

Malaysian scientists and researchers have collaborated and published joint publications with others (Figure 10.5). A large number of joint publications are with England, the USA, Australia and Japan, as well as with developing and emerging countries such as India, Iran and China. These countries attained a publication capacity of above 2,500 article publications over the period of 13 years. Joint publications – with advanced as well as emerging countries – implies Malaysia's commitment to learn and benefit from the spillover of knowledge, and to explore new niches in science and technology development.

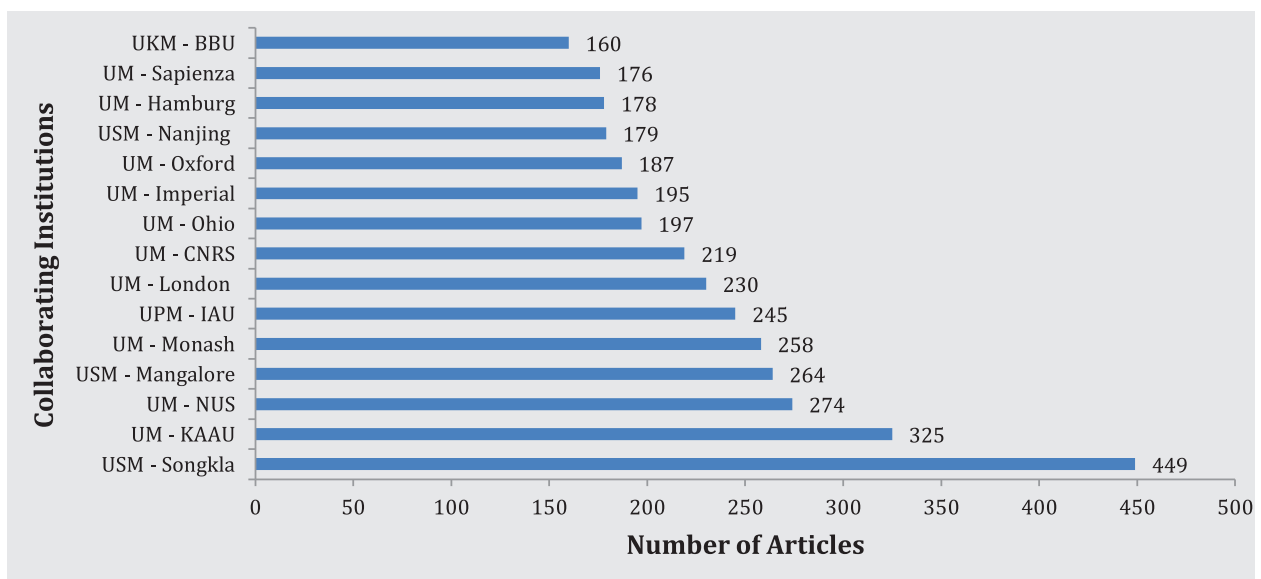
USM and Prince of Songkla University joint efforts for publication in science stands out as the most productive collaboration (Figure 10.6), while UM and King Abdulaziz University, UM and National University of Singapore, USM and Mangalore University, and UM and Monash University are among the top five collaborations that attained a capacity of 250 publications. For social science, UM and Monash University, UM and University of London, UM and Yale University, UM and National University of Singapore, and USM and University of Waterloo are the top five collaborations in terms of joint publications.

Figure 10.5 Joint Publications with Collaborating Countries, 2001 - 2014



Source : Bibliometric Study 2015

Figure 10.6 Top 15 Collaborating Institutions Abroad, Number of Articles, 2001 - 2014

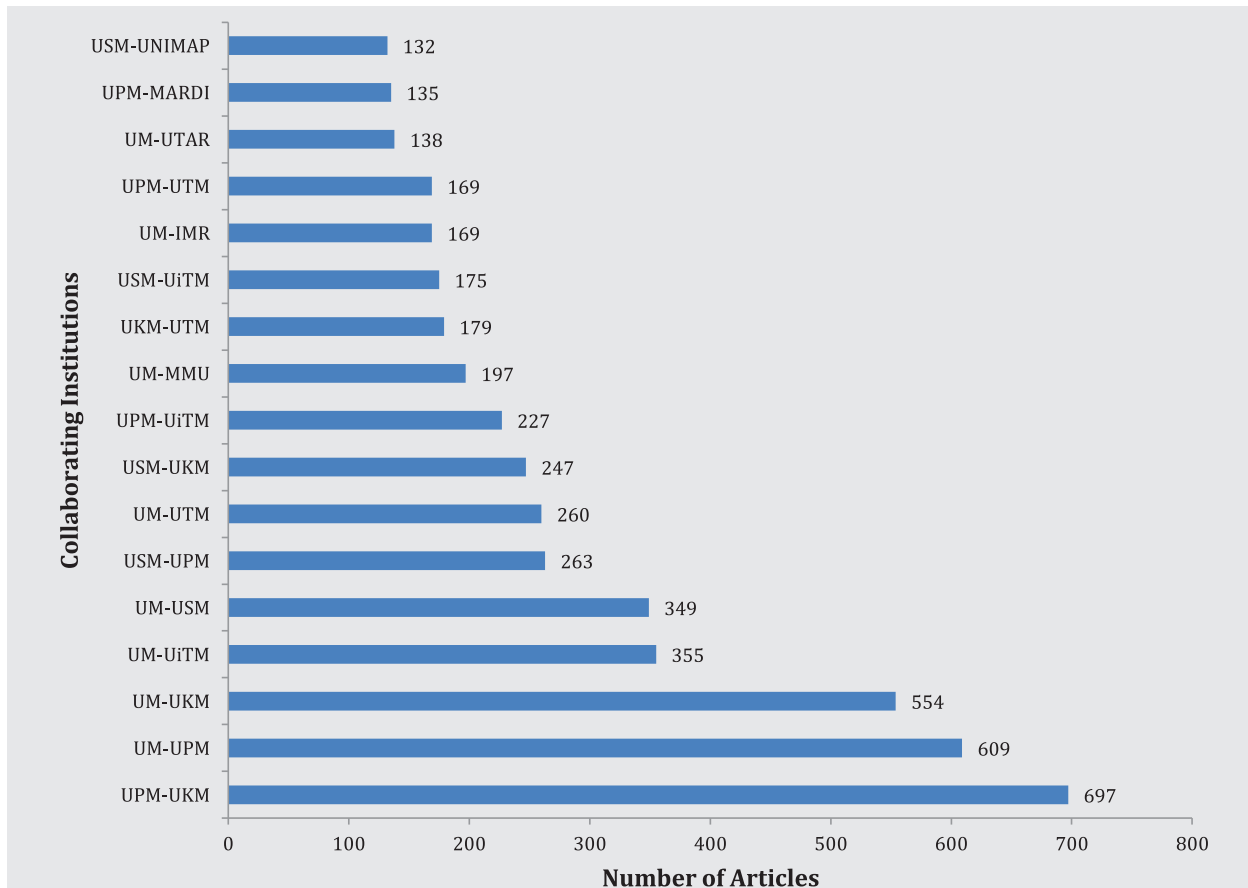


Note : Collaborations with more than 50 publications is set as threshold
 Source : Bibliometric Study 2015

10.3.2 National Collaboration

For science, collaboration between UPM and UKM produced 697 articles over a period of 13 years (Figure 10.7). Similarly, UM and UPM produced more than 500 articles for the period of 2001 – 2014, as did UM and UKM. For social science, UM and UKM stand out in producing large numbers of joint publications, which was also achieved by UKM and UPM. The productive joint research can be attributed to the close proximity between these universities.

Figure 10.7 Top Collaborating National Institutions, 2001 – 2014



Note : Collaborations with more than 130 publications is set as threshold

Source : Bibliometric Study 2015

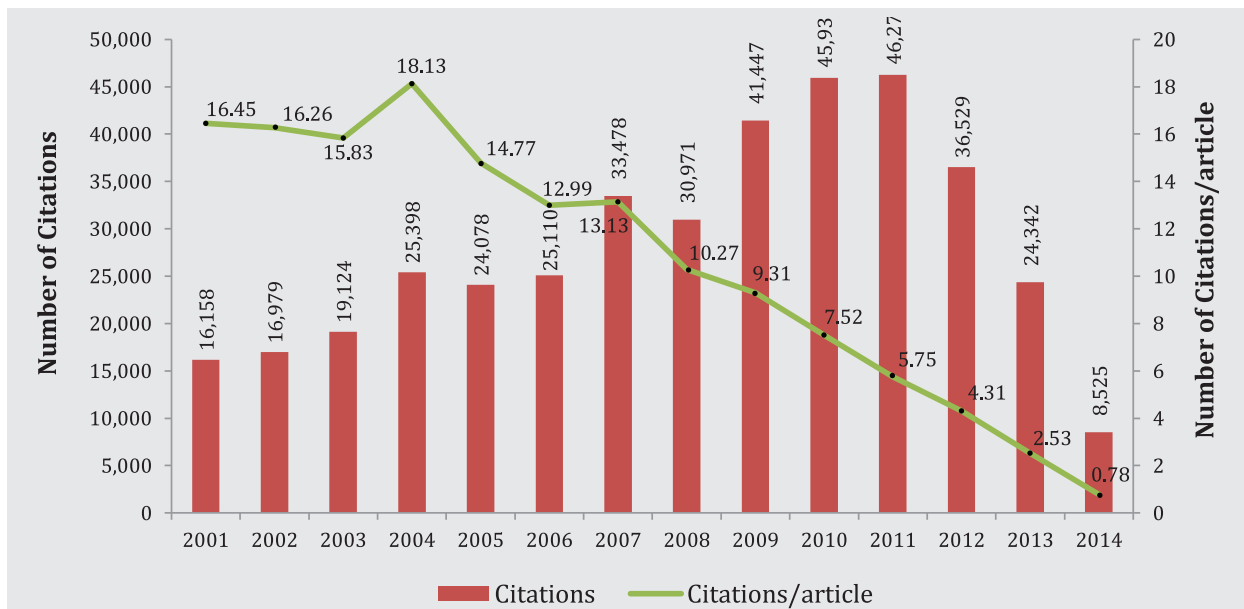
10.4 Impacts of Malaysia's Articles

Figure 10.8 shows Malaysia's citations count and citations per article. The citations count has been increasing since 2001, and reached its peak in 2011. The increasing citations trend in tandem with publications reflects the impact of Malaysia's scientific research activities. One can observe that the early publications are more likely to attain higher citations per article²⁴. Malaysia attained a total of 46,275 citations in 2011. Malaysia witnessed an eventual drop

²⁴ There is a slight difference in terms of reported figures for the annual total count of Malaysia's articles compared to those being used to calculate citations per article in Figure 10.8. Those used for Figure 10.8 are computed via the summation of two different categories of articles that were classified as science and social science.

in citation counts since then, with recent publications (since 2012) yet to complete the full cycle of citations – usually a 5 year window period.

Figure 10.8 Articles and Citations per Article, 2001 – 2014



Source : Bibliometric Study 2015

Table 10.3 records the citation counts and citations per article for top fields of research that reflect the publication impacts. Chemistry received the highest citation counts. Nevertheless, citations per article is rather modest. Environment/Ecology together with Biology and Biochemistry stand out as the two most impactful fields in term of citations per article. This reflects the interests of scientists – both local and international – in valuing research performed by Malaysian scientists in these two fields.

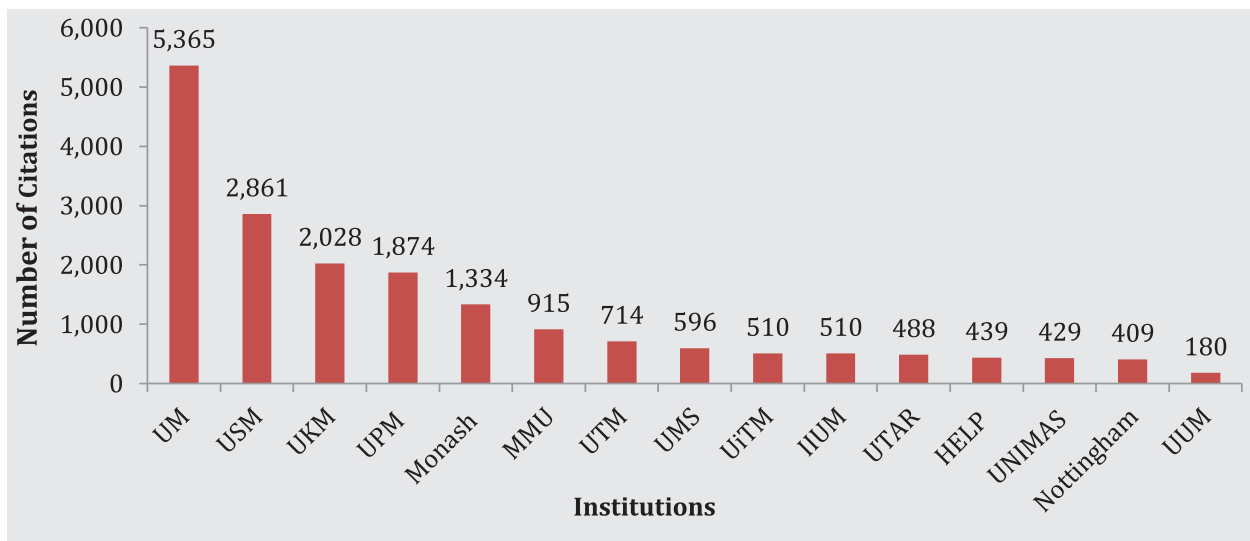
Table 10.3 Article Citations by Fields, 2001 – 2014

Research Fields	Citations	Citations/Article
Chemistry	56,673	5.25
Engineering	44,548	5.33
Clinical Medicine	37,233	6.11
Materials Science	23,220	4.61
Environment/Ecology	22,553	8.72
Agricultural Sciences	17,489	5.9
Biology & Biochemistry	16,878	8.03
Physics	15,425	4.72
Plant & Animal Science	13,016	4.53
Pharmacology & Toxicology	10,599	5.44

Source : Bibliometric Study 2015

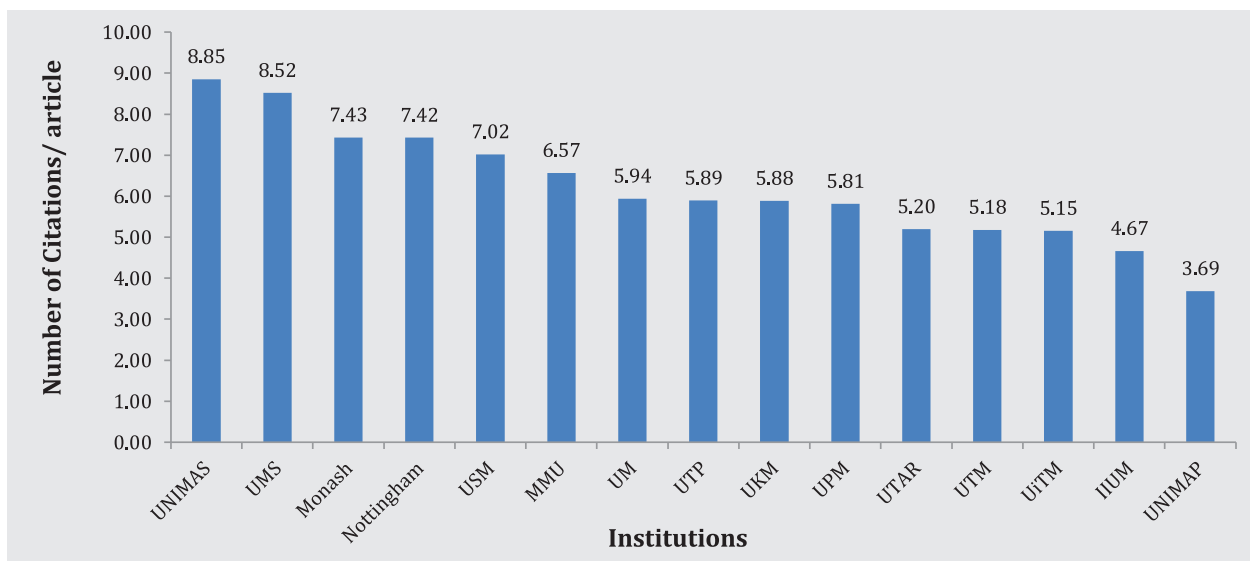
Figure 10.9 shows the article citation counts for social science by institutions. UM stands out as the leading institution in terms of citation counts (5,365), corresponding to the increasing amount of article publications over the years. USM, UKM and UPM are among the top performing institutions in terms of citation counts, producing more than 1,000 citations over 13 years. Monash University stands out as the private institution of higher learning performing at a level comparable to the top public institutions. UNIMAS and UMS emerged as the top performing institutions in terms of citations per article (Figure 10.10). This is followed closely by the impact made by two private institutions, namely Monash University and Nottingham University, Malaysia Campus. Among the RUs, USM stands out with 7.02 citations per article.

Figure 10.9 Social Science Article Citations by Institutions, 2001 – 2014



Source : Bibliometric Study 2015

Figure 10.10 Citations per Article by Institutions, 2001 – 2014



Source : Bibliometric Study 2015

10.5 h-Index

The h-index of an institution indicates the relative importance, significance and broad impact of an institution in terms of cumulative research contributions. Table 10.4 reports the h-indexes in different time periods (windows of four years) for top institutions in Malaysia. UM leads in three different time periods, while USM leads in the period of 2005 – 2008. The five RUs stand out as the top five institutions, attaining an h-index above 20 for the period of 2012 – 2014.

Table 10.4 Top Institutions by h-Index, 2001 – 2014

Institution	2001-2004	2005-2008	2009-2011	2012-2014
Universiti Malaya (UM)	59	57	51	35
Universiti Sains Malaysia (USM)	58	62	48	30
Universiti Putra Malaysia (UPM)	53	46	40	28
Universiti Kebangsaan Malaysia (UKM)	42	42	39	26
Universiti Teknologi Malaysia (UTM)	33	35	34	28
Universiti Teknologi MARA (UiTM)	20	27	26	16
Multimedia University (MMU)	25	29	21	12
Monash University	19	25	32	17
Universiti Malaysia Perlis (UNIMAP)	-	11	17	15
International Islamic University Malaysia (IIUM)	15	20	19	10
Universiti Teknologi Petronas (UTP)	12	19	27	14
University of Nottingham Malaysia	-	25	28	17
Universiti Tunku Abdul Rahman (UTAR)	7	17	22	11
Universiti Malaysia Sabah (UMS)	21	27	21	11
Universiti Malaysia Sarawak (UNIMAS)	23	24	20	12

Source : Bibliometric Study 2015

10.6 International Comparison

10.6.1 Publications and Citations

Table 10.5 reports the total article counts and share of total for selected countries. The USA remains the dominant country that leads in terms of scientific publications. China and Germany are ranked as second and third highest performing countries respectively in producing scientific publications. Singapore and Malaysia are in the 30s, while emerging countries in Southeast Asia such as Vietnam, Indonesia and the Philippines are placed at 60, 63 and 70 respectively.

Table 10.5 Total Count of Articles and Share of Total, 2006 – 2015

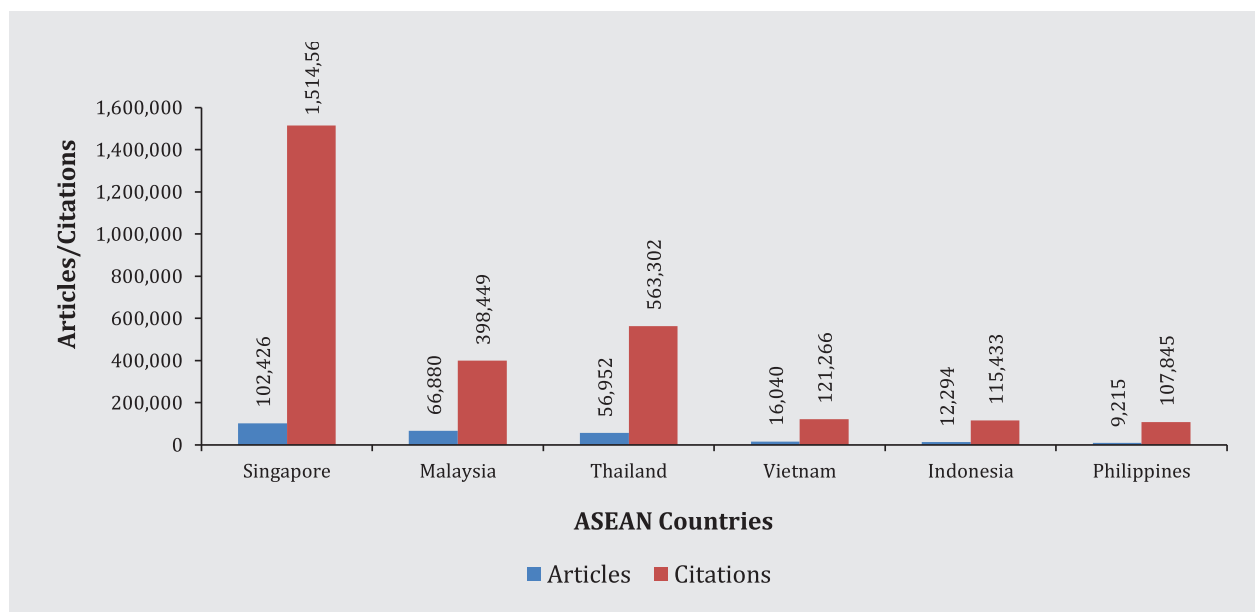
No.	Countries	Articles	% of Total
1	USA	3,773,427	21.59
2	Republic of China	1,657,047	9.48
3	Germany	988,153	5.65
4	England	891,184	5.10
5	Japan	844,743	4.83
6	France	697,105	3.99
7	Canada	605,129	3.46
8	Italy	582,608	3.33
9	Spain	496,756	2.84
10	India	469,564	2.69
11	Australia	461,499	2.64
12	South Korea	452,102	2.59
13	Brazil	346,807	1.98
14	Netherlands	346,329	1.98
15	Russia	307,293	1.76
33	Singapore	102,426	0.59
39	Malaysia	66,880	0.38
44	Thailand	56,952	0.33
60	Vietnam	16,040	0.09
63	Indonesia	12,294	0.07
70	Philippines	9,215	0.05

Note : Only 155 Countries were tracked by Essential Science Indicators (ESI). ESI tracks Highly Cited Papers that meet specific Citation Thresholds in order to visualise the impact of Countries, Institutions and Research Areas.

Source : Essential Science Indicators 2006 – 2015, extracted on 10 May 2016

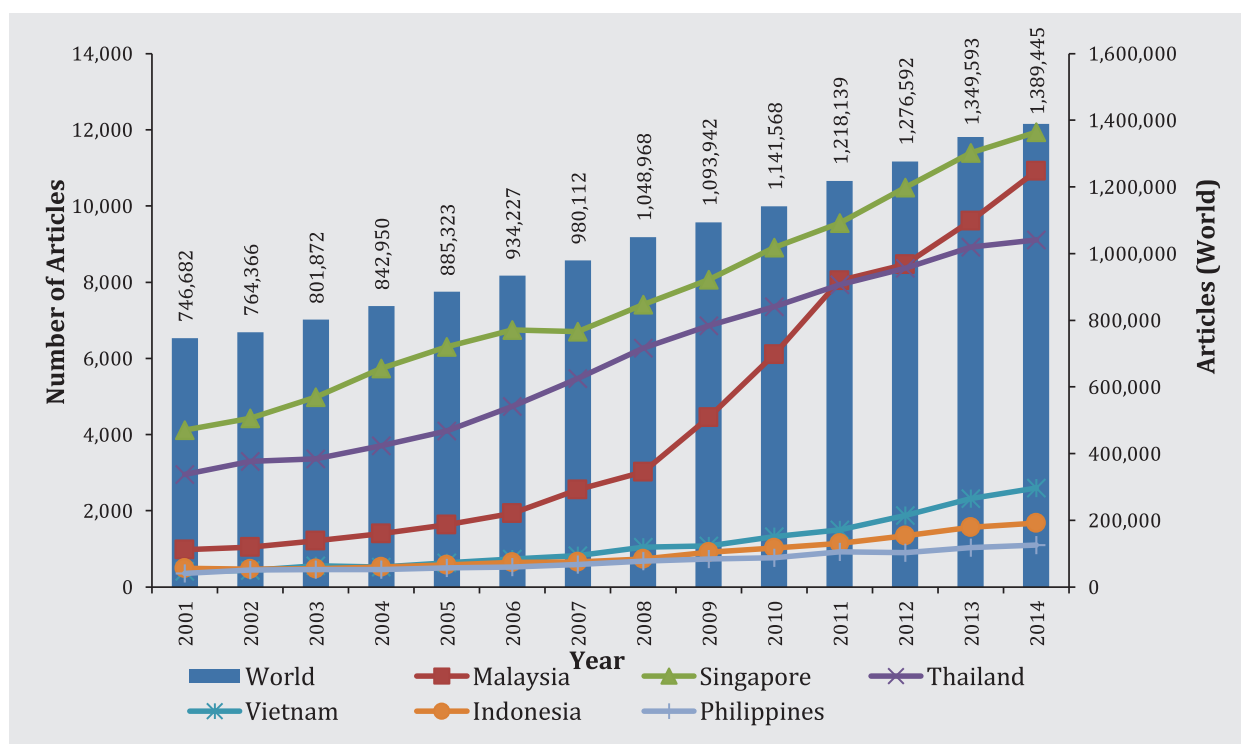
Figure 10.11 shows the article counts and cumulative citations from the past ten years, i.e. 2006 – 2015. Within ASEAN, Singapore stands out as the top performer in terms of number of articles and citations. Thailand has fewer articles but more citation counts than Malaysia. Singapore, Thailand and Malaysia witnessed a strong commitment in production of scientific publications and growth trends that seems to be consistent with that of the world. In addition, Malaysia has a steeply inclining curve in its scientific publications (Figure 10.12).

Figure 10.11 Articles and Citations, Selected ASEAN Countries, 2006 - 2015



Source : Essential Science Indicators 2006 - 2015

Figure 10.12 Number of Articles, Selected ASEAN Countries and the World, 2001 - 2014



Source : Bibliometric Study 2015 (Malaysia) and Thomson Reuters Web of Science 2001 - 2014 SCIE and SSCI (Other Countries).

Malaysia has improved its share in the total selected ASEAN publications, with its contributions significantly increasing from 10.54% in 2001, to 29.24% in 2014 (Table 10.6). Singapore and Thailand maintained their performance at above 30% and above 20% respectively. An increasing trend in the share of publications is observed in the case of Vietnam.

Table 10.6 Share of Selected ASEAN’s Total Articles, 2001 – 2014

Year	Malaysia	Singapore	Thailand	Vietnam	Indonesia	Philippines
2001	10.54	44.17	31.76	4.44	5.29	3.79
2002	10.31	43.80	32.57	4.34	4.62	4.36
2003	10.94	45.13	30.50	5.01	4.30	4.13
2004	11.34	46.40	29.99	4.24	4.28	3.75
2005	11.86	45.85	29.80	4.65	4.19	3.65
2006	12.63	44.04	30.93	4.77	4.23	3.40
2007	15.17	39.86	32.56	4.93	3.93	3.55
2008	15.73	38.71	32.71	5.44	3.86	3.56
2009	20.15	36.51	31.01	4.90	4.12	3.31
2010	23.97	34.94	28.87	5.17	4.03	3.03
2011	27.63	32.82	27.26	5.17	3.93	3.19
2012	26.93	33.35	26.60	5.97	4.28	2.87
2013	27.57	32.70	25.60	6.66	4.50	2.98
2014	29.24	31.97	24.40	6.95	4.49	2.94

Source : Bibliometric Study 2015 (Malaysia) and WoS, SCIE and SSCI (Other Countries), 2001 – 2014

10.6.2 Citations According to Fields of Research

Table 10.7 provides an overview of the fields that received relatively high impact in terms of citations per article. Immunology, Environment/Ecology and Space Science emerged as the most impactful fields in Malaysia. These are the top three fields in terms of citations per article. However, the impacts of all the selected fields seem to be lacking behind that of the top performers. The USA appeared as the leading country for all the selected fields. It is noteworthy that in the field of Engineering, Malaysia is catching up with the USA, given the gap is smaller in terms of citations per article.

Table 10.7 Citations of 22 Fields of Research, Malaysia and USA, 2001 – 2014

Research Field	Malaysia			Top Country in the List			
	Articles	Citations	Citations/ Paper	Country	Articles	Citations	Citations/ Paper
Immunology	542	5,885	10.86	USA	91,764	2,413,886	26.31
Environment/ Ecology	2,586	22,553	8.72	USA	107,091	1,815,319	16.95
Space Science	52	447	8.6	USA	65,768	1,517,866	23.08
Biology & Biochemistry	2,101	16,878	8.03	USA	325,136	6,978,525	21.46
Microbiology	867	6,250	7.21	USA	56,913	1,265,234	22.23
Neuroscience & Behaviour	474	3,307	6.98	USA	184,962	4,445,512	24.03
Molecular Biology & Genetics	853	5,758	6.75	USA	166,748	5,906,484	35.42
Clinical Medicine	6,095	37,233	6.11	USA	776,866	14,362,509	18.49
Agricultural Sciences	2,964	17,489	5.9	USA	65,776	701,289	10.66
Multidisciplinary	226	1,230	5.44	USA	11,396	717,875	62.99
Pharmacology & Toxicology	1,949	10,599	5.44	USA	92,875	1,583,802	17.05
Engineering	8,364	44,548	5.33	USA	209,866	1,610,435	7.67
Chemistry	10,801	56,673	5.25	USA	250,294	5,137,017	20.52
Psychiatry/ Psychology	489	2,518	5.15	USA	159,540	2,395,099	15.01
Geosciences	914	4,512	4.94	USA	114,779	1,901,712	16.57
Physics	3271	15,425	4.72	USA	259,613	4,462,051	17.19
Materials Science	5,038	23,220	4.61	USA	94,174	1,578,956	16.77
Plant & Animal Science	2,876	13,016	4.53	USA	168,587	1,974,340	11.71
Social Sciences, General	2,291	7,127	3.11	USA	29,5871	2,435,330	8.23
Economics & Business	818	2,137	2.61	USA	87,388	967,566	11.07
Computer Science	1,837	4,472	2.43	USA	86,941	701,645	8.07
Mathematics	1,163	2,791	2.4	USA	87,253	48,0157	5.5

Source : Bibliometric Study 2015

10.7 Summary

Malaysia witnessed an expansion in its publication capacity, from producing 5,933 articles in 2010 to 10,499 in 2014. This can be attributed to the increase in public research funding and other promotion of development of scientific activities. Indeed, it indicates that Malaysian scientists have the ability to perform scientific research activities. While many public universities have performed remarkably well in publication, i.e. at par, few private universities have performed equally well in terms of number of articles and citations per article. Malaysia – along with other performing countries in Southeast Asia – has witnessed a sharp increase in scientific publications, manifesting a strong commitment in science that is consistent with the world. Engineering stands out as the most impactful field in Malaysia, comparable to that of the top countries in the world.



Intellectual Property Rights

The most productive organisations
in patenting in MyIPO

MIMOS, UTM

Top organisations patenting in PCT

MIMOS, UPM, Intel, USM, UM, MPOB

The top three performing countries for patent and
utility innovations in MyIPO

USA, Japan, Malaysia

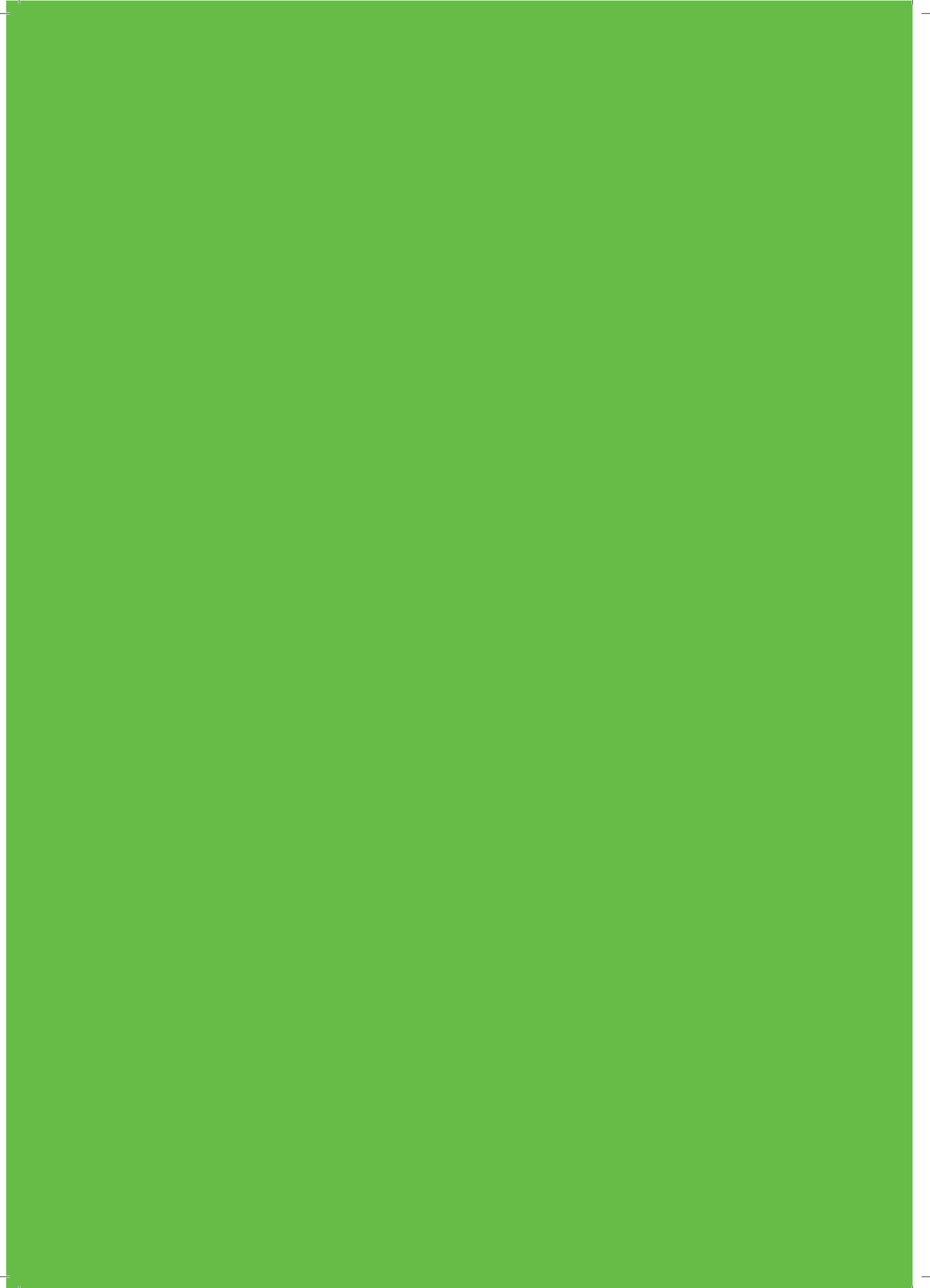
Top five fields of technology in terms of share of total of
Malaysia's PCT patents

- Computer Technology
- Digital Communication
- Measurement
- Semiconductor
- Telecommunications

Chemistry; Metallurgy
contributed a total share of

27.36%

of the total granted patents
between 2011 and 2015 in
MyIPO



CHAPTER 11: INTELLECTUAL PROPERTY RIGHTS

11.1 Introduction

Intellectual property serves as an important STI indicator in measuring Malaysia's progress in innovation activities. This chapter reviews and assesses the performance of intellectual property – namely, patenting – in Malaysia, using the National Bibliometric Study 2015 as the base. It reports the statistics on Malaysian patents applied and granted under the Patent Cooperation Treaty (PCT) of the World Intellectual Property Organisation (WIPO)²⁵ and the Intellectual Property Corporation of Malaysia (MyIPO) respectively. The chapter further provides insights on top fields of technology and the performing institutions. Like in the chapter on scientific publications, this chapter reports the joint patenting trends in order to reflect the collaboration patterns for technology markets. In addition, this chapter assesses the trademarks, industrial designs, and geographical indicators in order to provide insights on other types of intellectual property.

11.2 Patent and Utility Innovation – Local and Foreign Applicants

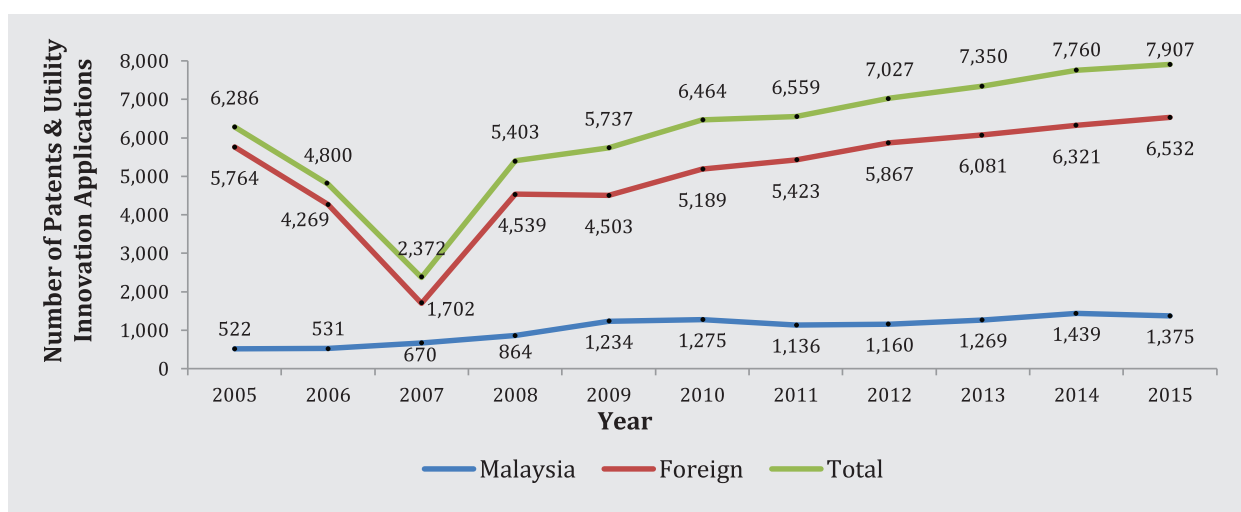
The Malaysian patent office, MyIPO is instrumental in promoting invention disclosures. It protects the interests of inventors via granting exclusive rights to their inventions for a period of time, and allows the inventors to trade their intellectual property in technological markets. There are two types of protection in securing the invention of an inventor, namely patent and utility innovation. Utility innovation is for those who are interested to claim the rights to their minor type of invention.

The share of utility innovation applications against total patent applications is low²⁶. There is a high correlation between foreign and total patent and utility innovation applications (Figure 11.1). Foreign applications are greater than local applications. There is also a significant drop in patent and utility innovation applications in 2006 and 2007. This is attributable to Malaysia's accession to PCT in 2006, which simplified the patent application process for foreign entities that have filed PCT applications in other countries. Nonetheless, the count for foreign applications recovered in 2008 and witnessed consistent growth thereafter. It is noteworthy that there is an increase in Malaysia's production capacity for two periods of time, namely 2006 – 2009 and 2011 – 2014. While 2006 – 2009 witnessed an increase from 531 patents in 2006 to 1,234 patents in 2009, 2011 – 2015 manifested an increase in capacity from 1,136 patents in 2011, to 1,375 patent and utility innovations in 2015. Malaysian inventors applied for a total of 11,475 patent and utility innovations during 2005 – 2015.

²⁵ This is based on the Bibliometric Study 2015. The data was extracted via a subscribed patent database (Patsnap) and the data filtering was done by assessing the addresses of assignees of Malaysia's PCT applications.

²⁶ It has been reported that utility innovation applications attributed 1.38%–2.14% for the period of 2009 – 2013. See Wong, C-Y. and Salmin, M.M. (2016).

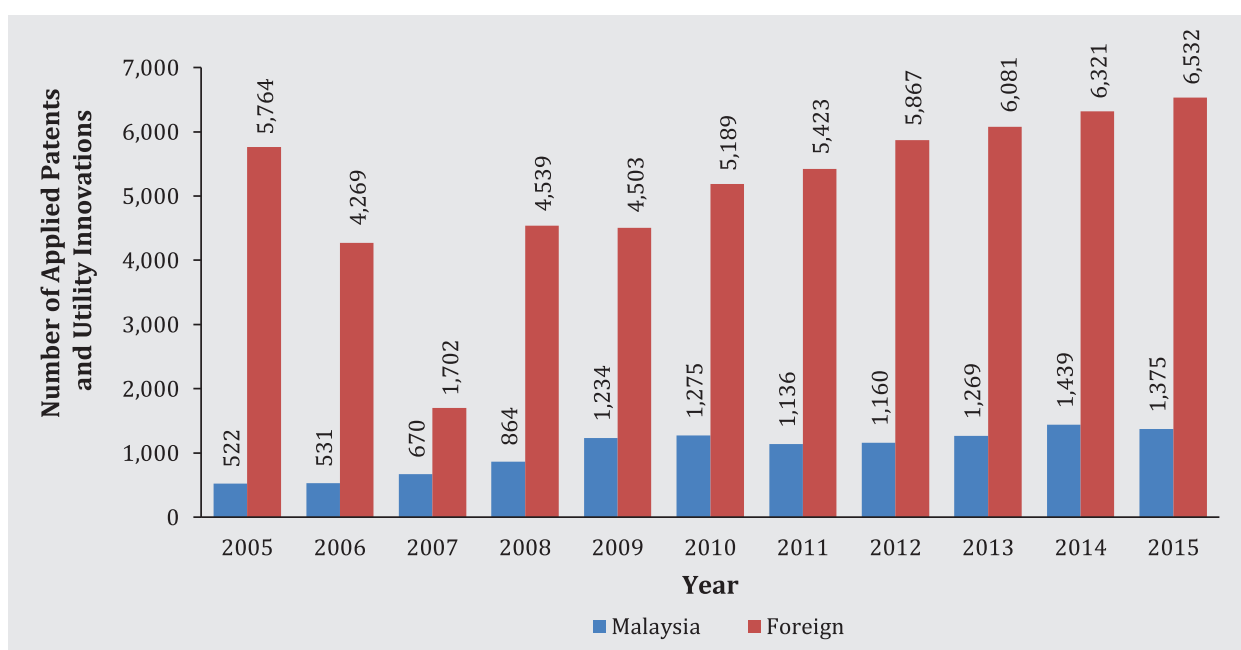
Figure 11.1 Patent and Utility Innovation Applications, 2005 – 2015



Source : MyIPO, 2016

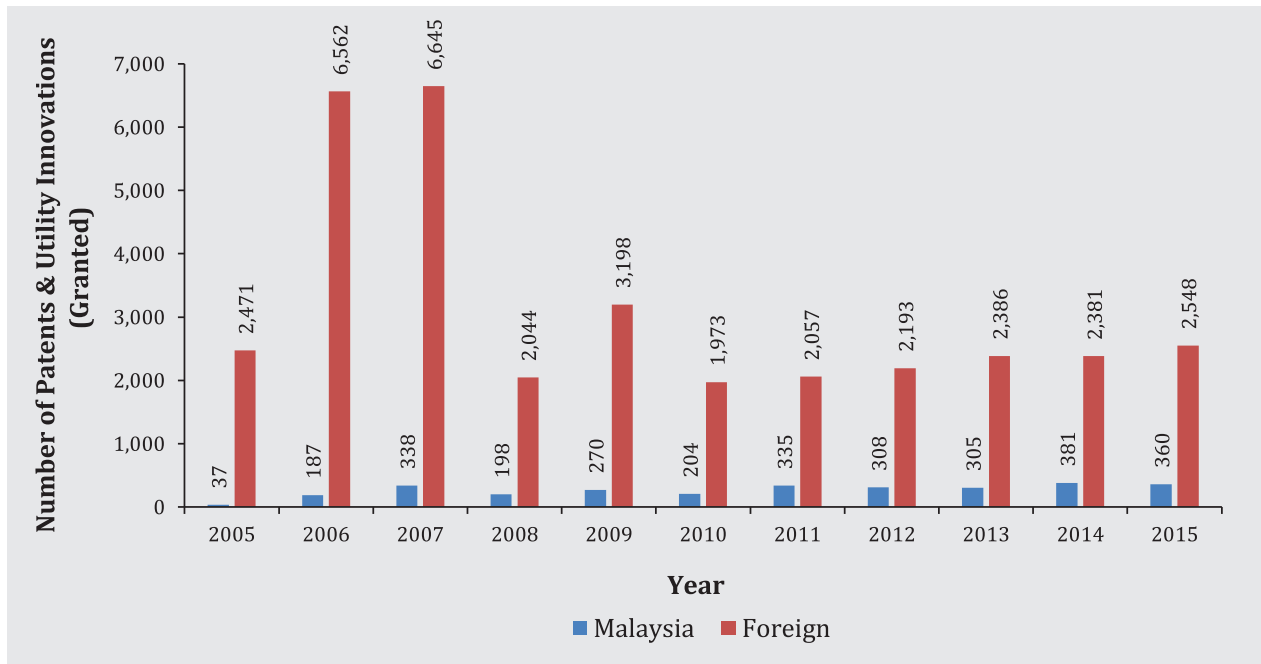
The share of Malaysia’s patent and utility innovation applications (lowest and highest percentage over the years) ranges from approximately 8% (522 applications) to 22% (1,234 applications) (Figure 11.2). The share attained in 2007 (28%) was an exception due to lower applications by the foreign inventors. Nonetheless, the share of patents and utility innovations granted to Malaysian inventors exhibits an increasing trend (Figure 11.3), from 9% in 2010 to more than 11% for the period of 2011 – 2015. Figure 11.4 manifests a gap between applications and granted patents and utility innovations since 2008. The count for granted patents is higher than the applications for the period of 2006 and 2007.

Figure 11.2 Number of Applied Patents and Utility Innovations, 2005 – 2015



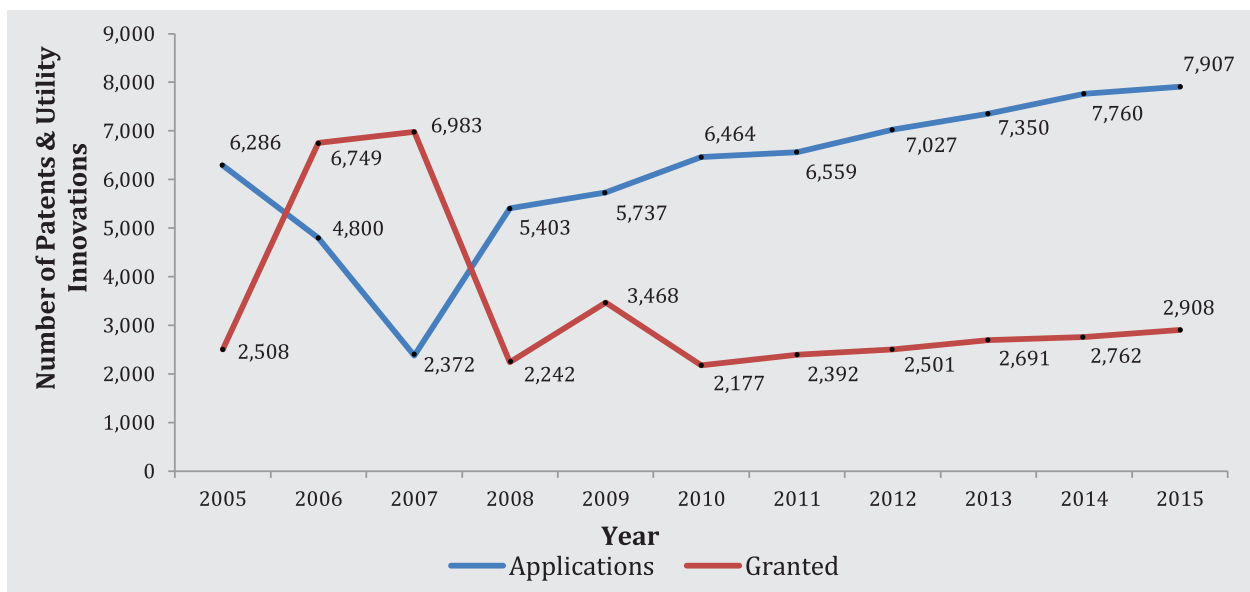
Source : MyIPO, 2016

Figure 11.3 Number of Granted Patents and Utility Innovations, 2005 - 2015



Source : MyIPO, 2016

Figure 11.4 Total Applications and Granted Patents and Utility Innovations, 2005 - 2015

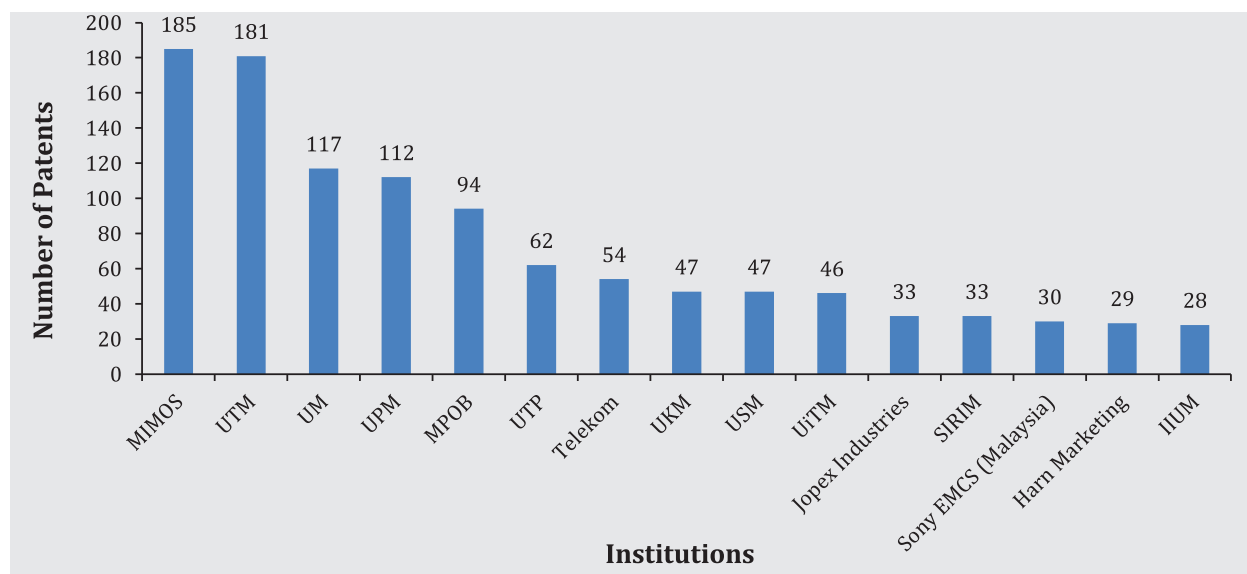


Source : MyIPO, 2016

11.2.1 Patent Applications by Organisations

MIMOS and UTM stand out as the most productive organisations in patenting, with a capacity of above 180 patents for 2005 – 2015 (Figure 11.5). This is followed by UM, UPM and MPOB. These organisations achieved above 80 patents from 2005 to 2015. Private organisations include Telekom Malaysia, Jopex Industries, SIRIM, Sony and Harn Marketing.

Figure 11.5 Top Assignees in Malaysian Patents, 2005 – 2015



Source : Bibliometric Study 2015

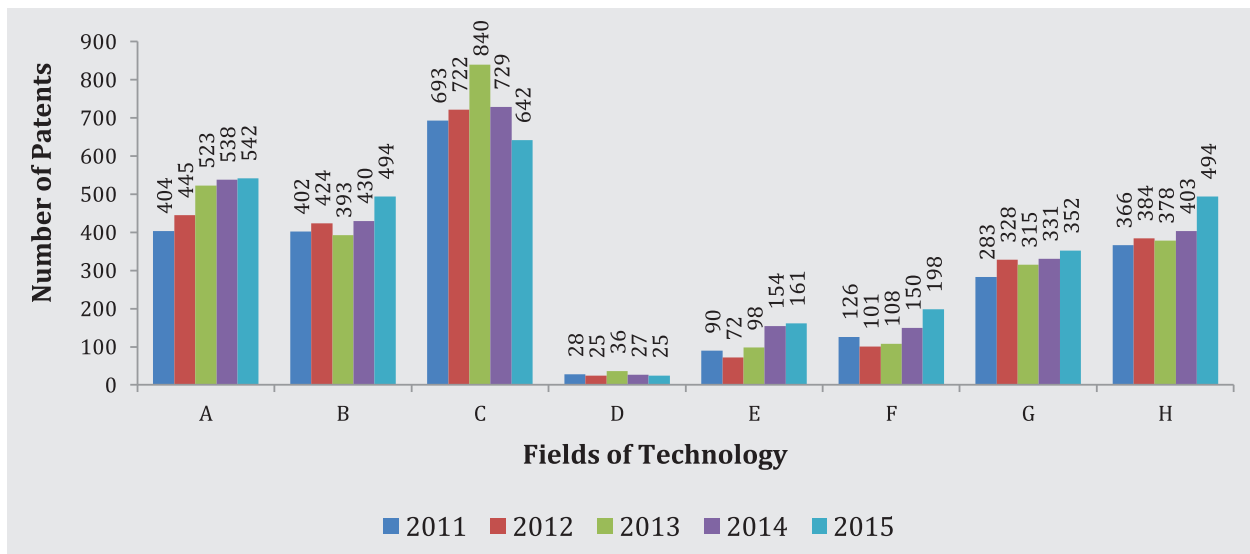
11.2.2 Granted Patents by Fields of Technology

Figure 11.6 presents the number of granted patents based on fields of technology. Human Necessities, Performing Operations; Transporting, and Chemistry; Metallurgy emerged as the top technologies. Chemistry; Metallurgy (Section C) attained a capacity of 840 granted patents in 2013. It contributed a total share of 27.36% of the total granted patents between 2011 and 2015. This is followed by Human Necessities (18.50%), Performing Operations; Transporting (16.17%), Electricity (15.28%), and Physics (12.14%). Mechanical Engineering; Lighting; Heating; Weapons; Blasting, as well as Fixed Construction, and Textiles; Paper contributed 5.15%, 4.34% and 1.06% respectively.

11.2.3 Top Performing Countries

The top three performing countries for patent and utility innovations in MyIPO are the USA, Japan and Malaysia (Figure 11.7). The number of applications by these countries has been consistently high – ranging between 1,592 and 1,826 applications for the USA, 877 and 1,495 applications for Japan, and 1,136 and 1,439 patent applications for Malaysia. The application footprints of China and other Asian advanced economies such as South Korea and Taiwan are emerging (Figure 11.7).

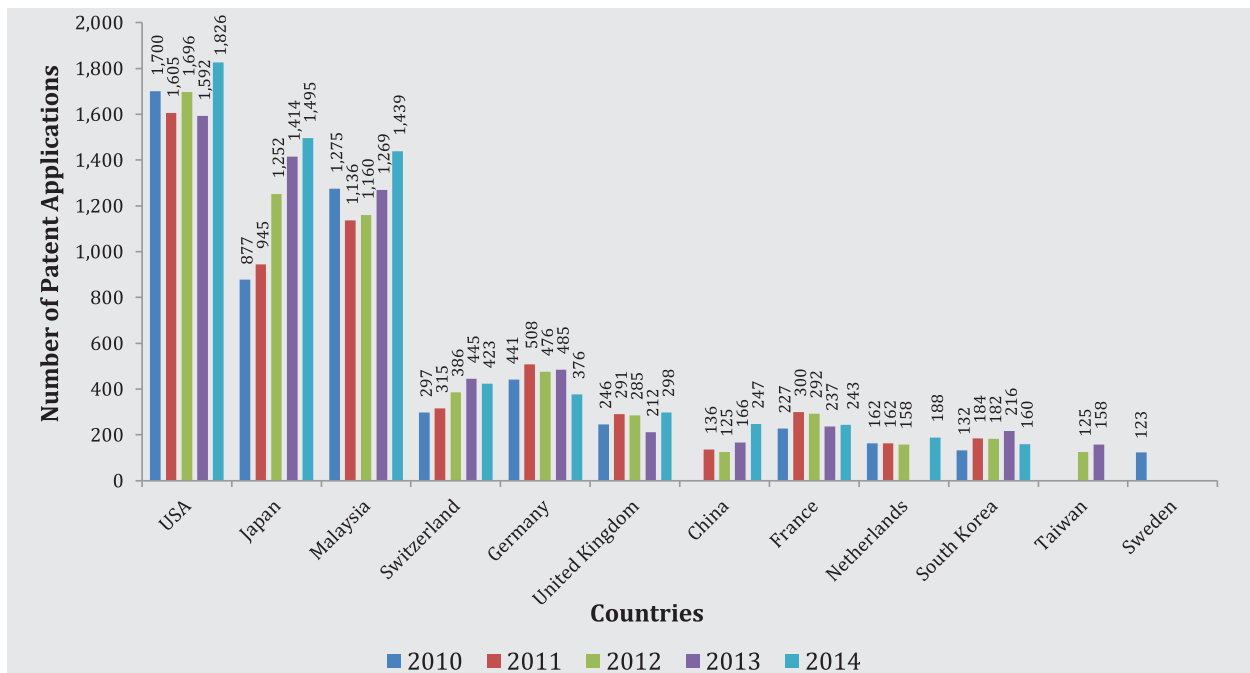
Figure 11.6 Granted Patents by Fields of Technology, 2011 - 2015



Source : MyIPO, 2016

- Section A: Human Necessities
- Section B: Performing Operations; Transporting
- Section C: Chemistry; Metallurgy
- Section D: Textiles; Paper
- Section E: Fixed Construction
- Section F: Mechanical Engineering; Lighting; Heating; Weapons; Blasting
- Section G: Physics
- Section H: Electricity

Figure 11.7 Top Countries for Patent and Utility Innovation Applications, 2001 - 2015



Source : MyIPO, 2016

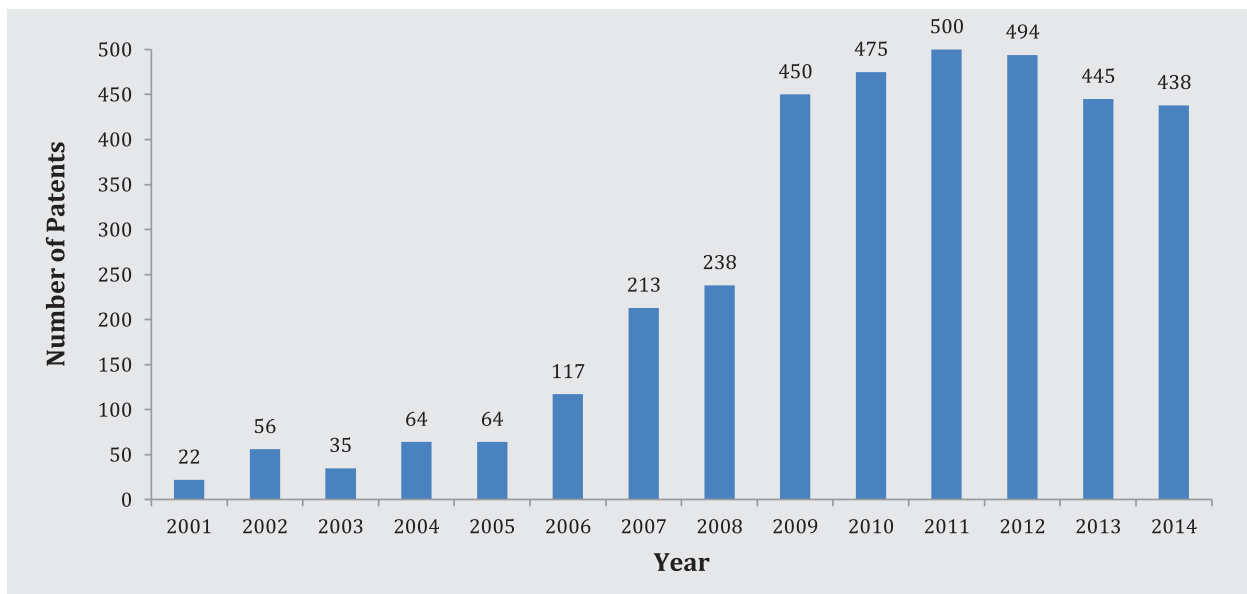
11.3 Patent Filing and Utility Innovations in the Patent Cooperation Treaty

The PCT is an international patent law treaty that provides a common procedure for inventors who wish to file patents in order to protect their inventions in any of the contracting states. There is a significant increase of patent applications, from just 238 in 2008 to 450 PCT patents in 2009 (Figure 11.8). The PCT patent production capacity has then remained at 438–500 patent applications.

MIMOS stands out as the most productive organisation for PCT patents (Figure 11.9). It accumulated 788 PCT patents from 2001 to 2014. Other organisations such as UPM and Intel are performing significantly behind MIMOS. USM and UM are among the performing public RUs in Malaysia. Private organisations such as Intel, PETRONAS and Schlumberger are among the performing firms that have accumulated 50 or more patents from 2001 to 2014.

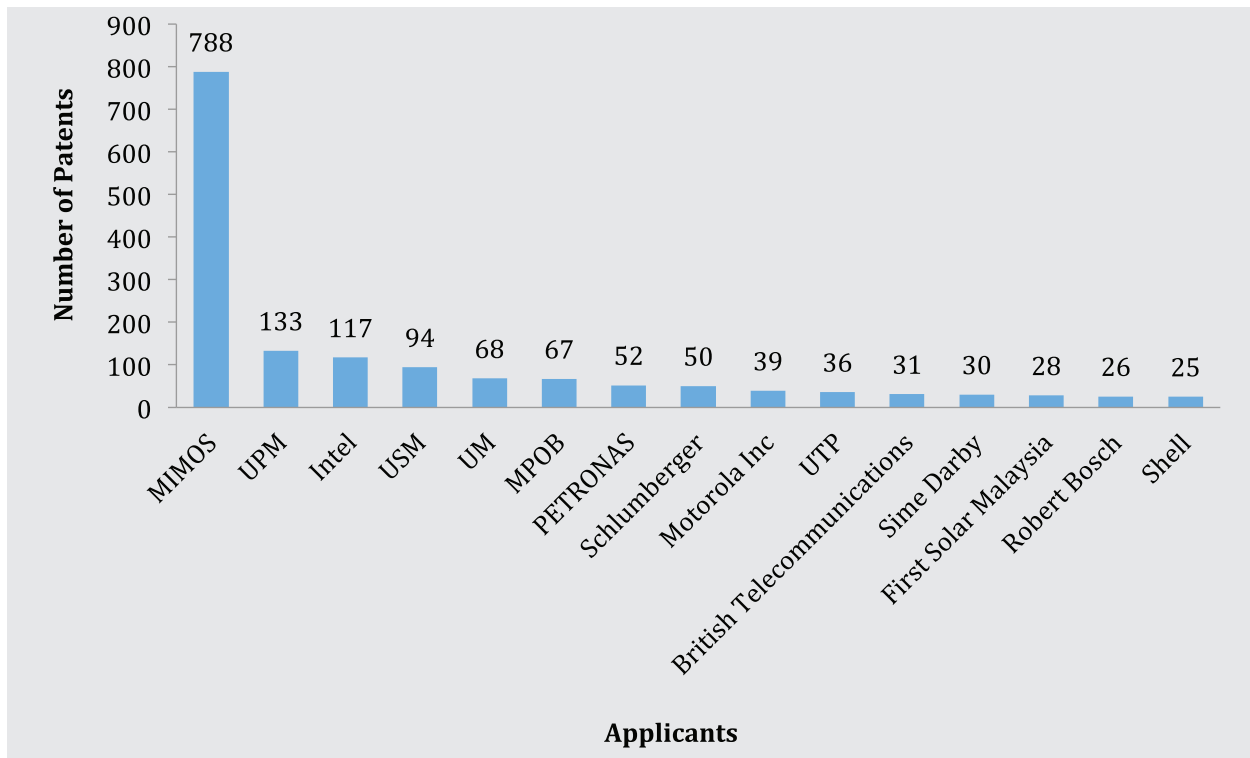
Computer Technology, Digital Communication, Measurement, Semiconductor, and Telecommunications are the top five fields of technology in terms of share of Malaysia’s total PCT patents (Figure 11.10). This implies the significant dominance of information and communication related technology in the Malaysian patent applications landscape.

Figure 11.8 Malaysian Assignees Patent Applications in PCT, 2001 - 2014



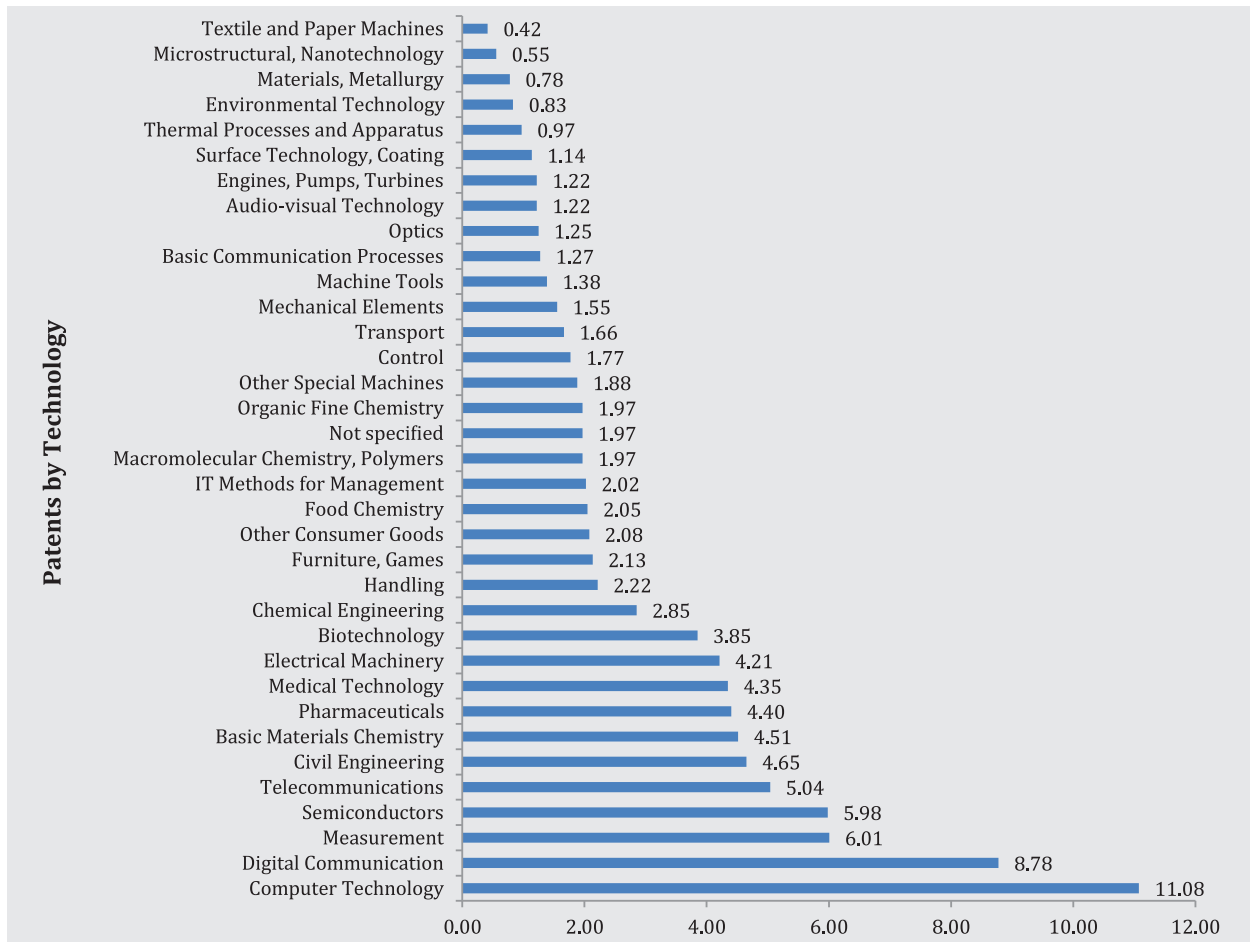
Source : Bibliometric Study 2015. Search criteria for patent applications in PCT was based on assignee's address.

Figure 11.9 Top Applicants in PCT, 2001 – 2014



Source : Bibliometric Study 2015

Figure 11.10 PCT Patents by Technology (% share of total), 2001 – 2014



Source : Bibliometric Study 2015

There is a consistent increase in terms of non-resident PCT applications that have selected Malaysia as their designated office (Figure 11.11). This indicates increasing interest of inventors abroad to secure IP protection in Malaysia. It is noteworthy that there is an increasing trend of Malaysians selecting foreign countries for the patent's designated offices, increasing from 189 entries in 2008 to 644 entries in 2014.

Figure 11.11 PCT National Phase Entry, 2008 – 2014



Note : The term "resident" is used for filings made by applicants at their home office. The term "non-resident" is used for filings in a foreign office. The term "abroad" is used for statistics by origin.

Source : WIPO IP Statistics Data Centre, 2016

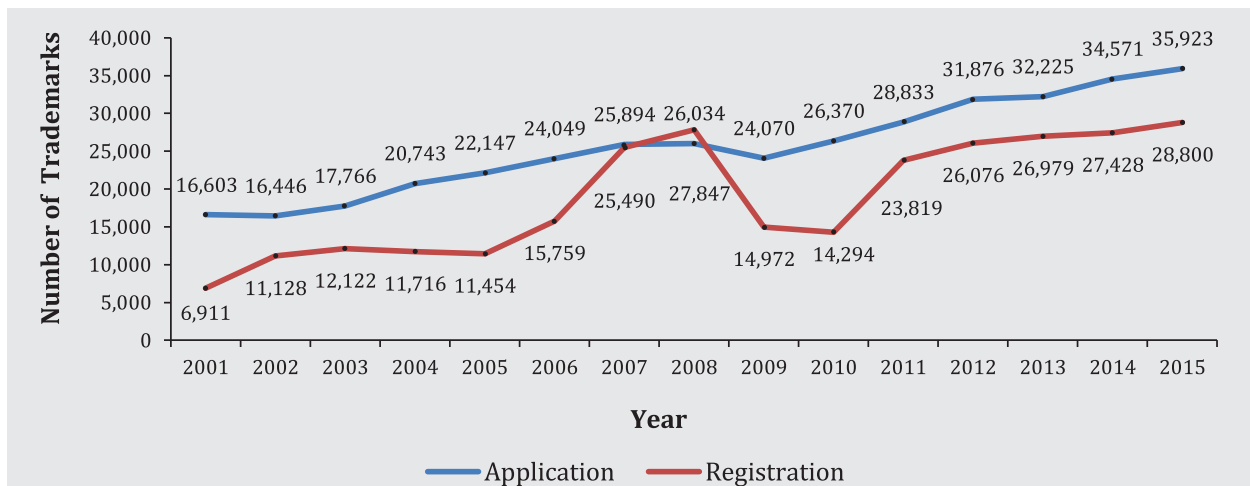
11.4 Trademarks

A trademark – which can be a word, logo, picture, name, letter, number, or a combination of these – is a sign that allows for recognition of the goods or services of a particular producer. Trademark statistics can be considered as a useful indicator for the efforts of marketing innovations, as it is instrumental for a producer to make their product or service distinguishable from other producers²⁷.

The trends in Figure 11.12 imply consistent efforts of innovative producers to perform marketing innovation in Malaysia. The applications have more than doubled in 2015 compared to 2001, while the registrations increased fourfold to 28,800 in 2015. The gap between applications and registrations has been stable for most of the years.

²⁷ See Mendonca, S. Pereira, T.S. and Godinho, M.M. (2004).

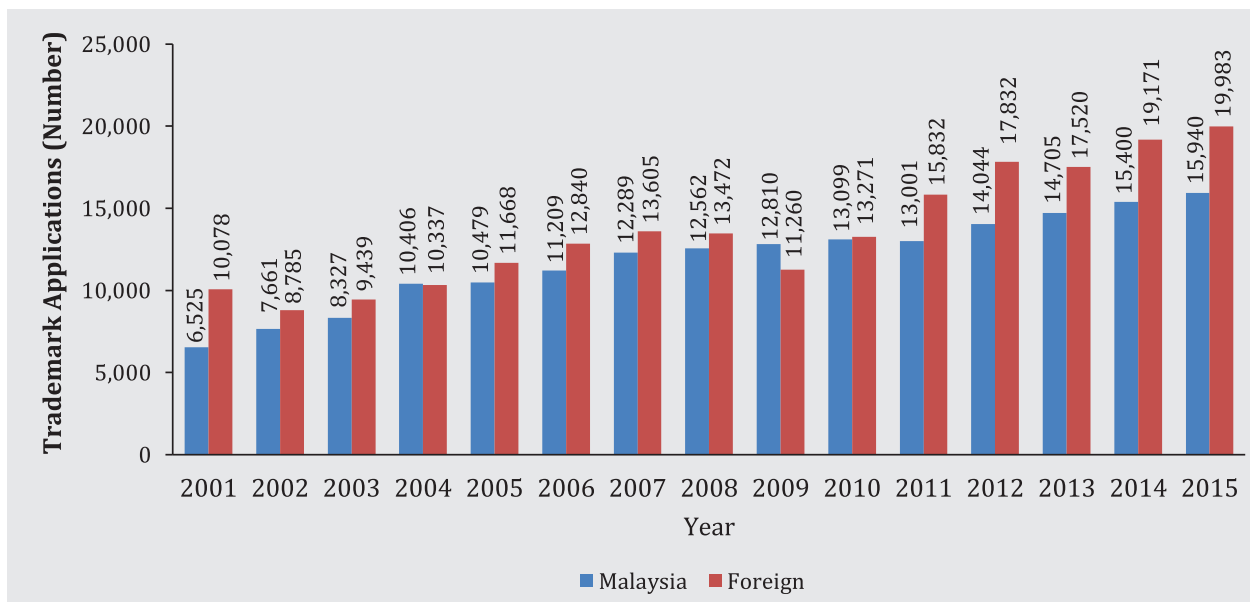
Figure 11.12 Application and Registration of Trademarks, 2001 - 2015



Source : MyIPO, 2016

The share between foreign and Malaysian applicants has been fairly consistent (Figure 11.13). Similar to the case for patents, foreign applications are greater than Malaysian applications in most of the years. Nevertheless, Malaysian applicants attained a share comparable to that of foreigners in some years. As a whole, the share is more balance compared to patent applications.

Figure 11.13 Applications of Trademarks, 2001 - 2015



Source : MyIPO, 2016

Comparing individual country shares indicates that Malaysia dominates the share of trademark applications (Table 11.1). It has a share of 54.12% in 2013, and 53.28% in 2014. This is followed by many developed countries such as the USA (12.47% in 2014), Japan (9.03%), the United Kingdom (4.31%), Singapore (4.23%), Germany (3.64%), France (3.24%), Switzerland (3.04%) and Taiwan (2.38%). China (4.37%) is the only emerging country that applied for a number of trademarks in Malaysia comparable to those of the United Kingdom and Singapore.

Table 11.1 Top Ten Countries, Trademark Applications (% share of total), 2008 – 2014

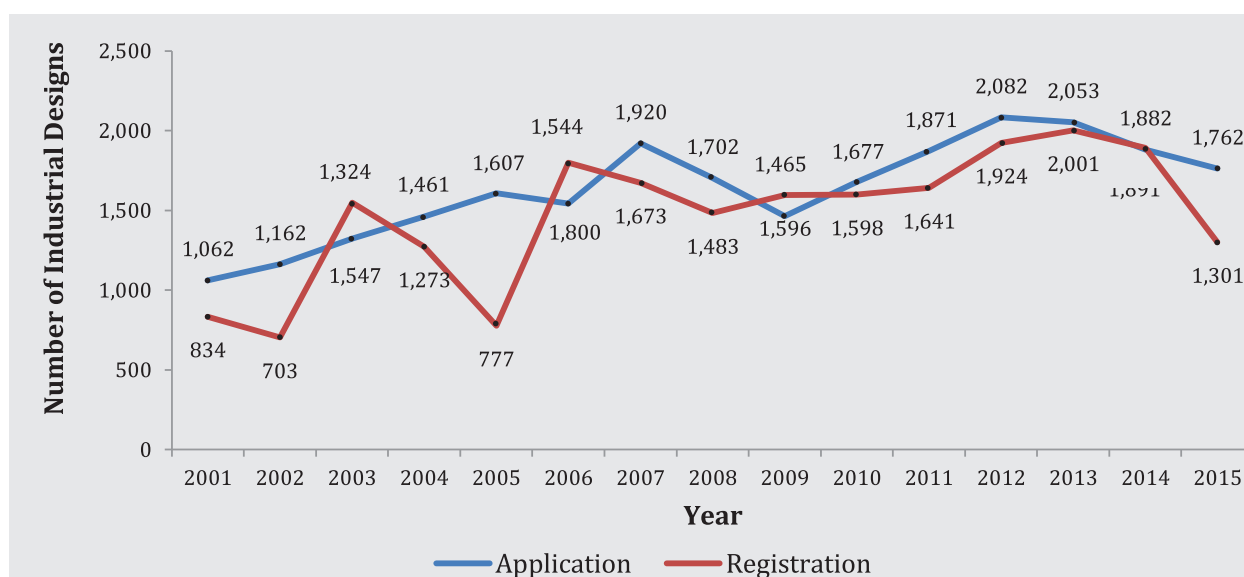
Country	2013	2014	% Share 2013*	% Share 2014*
Malaysia	14,705	15,400	54.12	53.28
USA	3,413	3,604	12.56	12.47
Japan	2,552	2,610	9.39	9.03
China	1,091	1,263	4.02	4.37
United Kingdom	985	1,246	3.63	4.31
Singapore	1,107	1,222	4.07	4.23
Germany	1,066	1,053	3.92	3.64
France	882	936	3.25	3.24
Switzerland	781	880	2.87	3.04
Taiwan	589	689	2.17	2.38
Total	27,171	28,903	100	100

Note : *% Share alludes to % of the total sum of trademarks among the top 10 countries

Source : MyIPO, 2016

11.5 Industrial Design

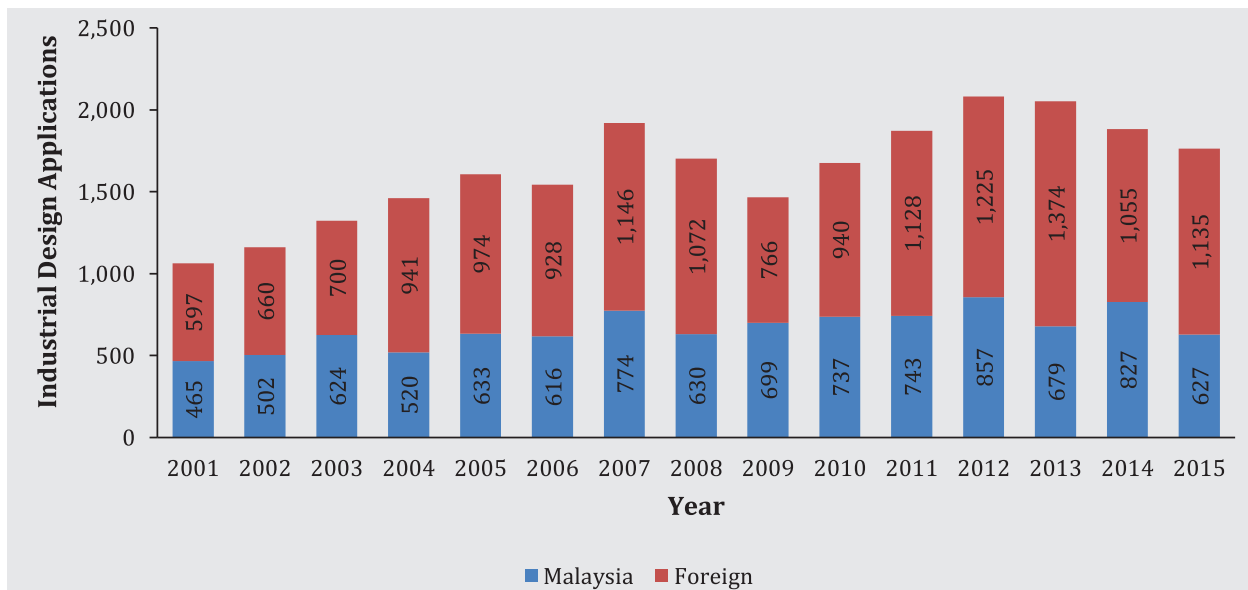
An industrial design protects certain ornamental and aesthetic aspects of an article. The application numbers for industrial design protection have increased from 1,062 in 2001 to 1,762 in 2015 (Figure 11.14). Malaysia witnessed considerably high applications for industrial designs in 2012 and 2013, reaching above the 2,000 mark. The gaps between applications and registrations have not been obvious.

Figure 11.14 Total Industrial Design Applications and Registration, 2001 – 2015

Source : MyIPO, 2016

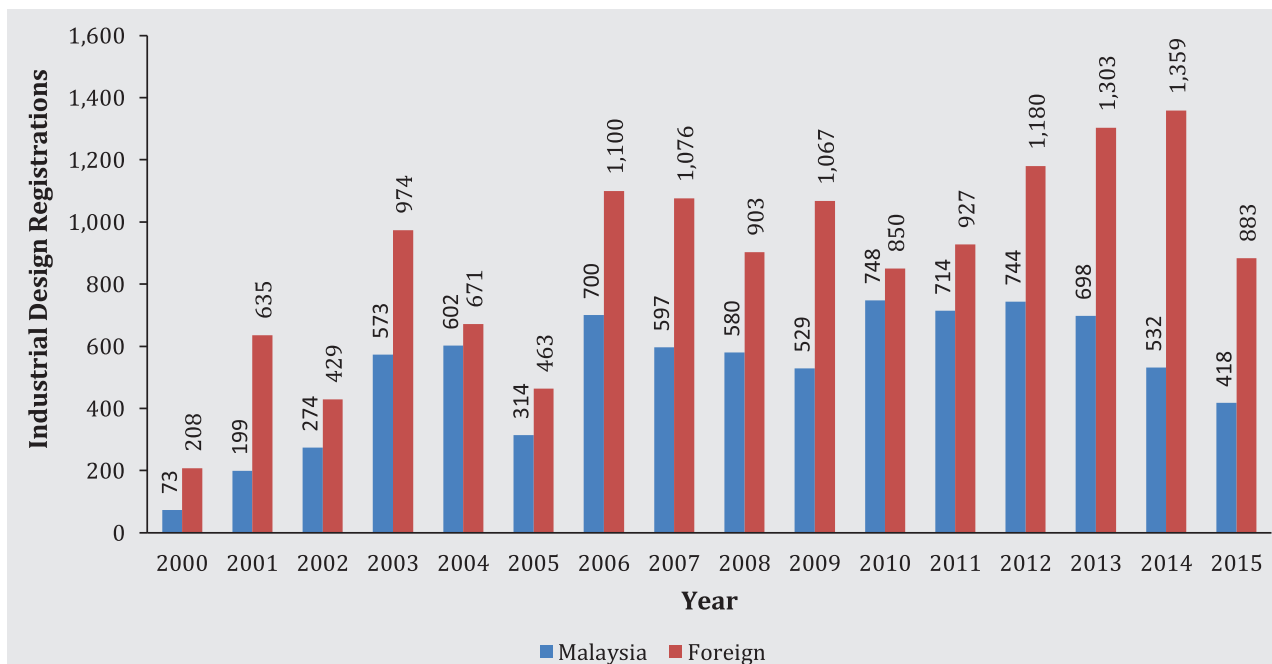
The share between foreign and Malaysian applicants seems to be relatively equal (Figure 11.15). The foreign applications increased from 597 in 2001 to 1,135 in 2015, while applications from Malaysians ranged between 465 in 2001 (being the lowest) to 857 in 2012 (the highest in the selected time period). A similar trend is observed for the share of Malaysian and foreign industrial designs registrations (Figure 11.16).

Figure 11.15 Share of Industrial Design Applications by Nationality, 2001 - 2015



Source : MyIPO, 2016

Figure 11.16 Share of Industrial Design Registration by Nationality, 2000 - 2015

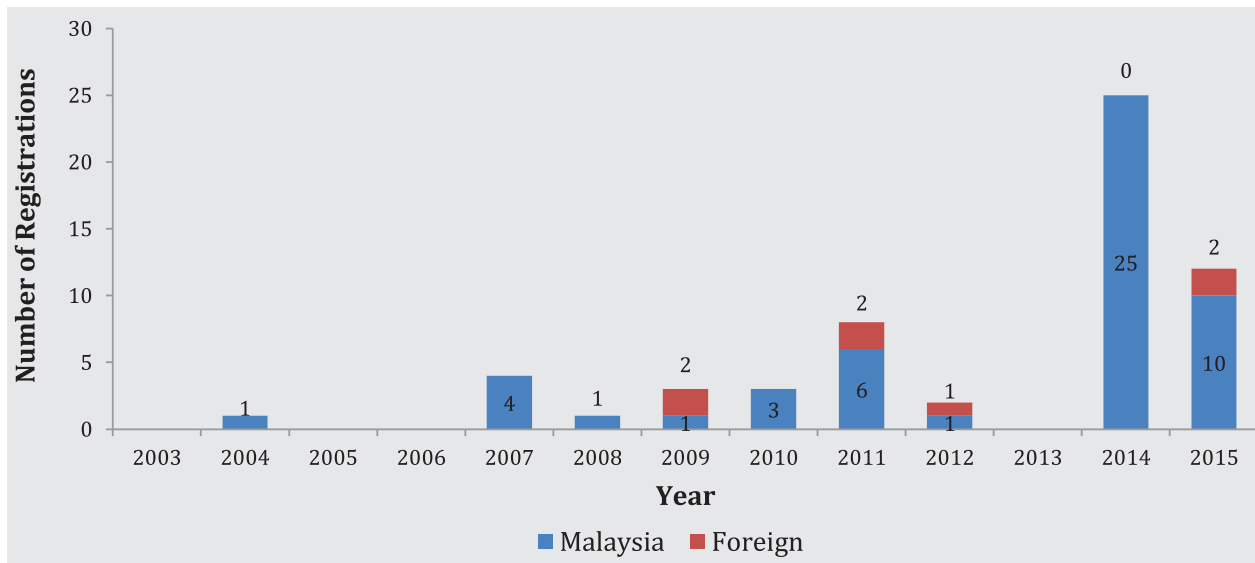


Source : MyIPO, 2016

11.6 Geographical Indications

Geographical Indications (GIs) reflect certain goods where a given quality, reputation or other characteristic is essentially attributable to their geographical origin (MyIPO, 2016). Malaysians seem to dominate the registration landscape (Figure 11.17). Table 11.2 lists the registered geographical indications that were reported with MyIPO.

Figure 11.17 Registration of Geographical Indications by Nationality, 2003 - 2015



Source : MyIPO, 2016

11.7 Trends in Global Applications and Grants

This section discusses the global trends in patent applications, including top applications by fields of technology and the trend among the selected middle-income countries.

11.7.1 Global Trends in Patent Applications

Table 11.3 demonstrates the applications trends of the top five countries in PCT patenting in the period of 2001 to 2014. Japan emerged as the top performing country in the 2000s, but the USA has outperformed it since 2013. China emerged as the most aggressive country in PCT patenting – from lagging behind with only 31,233 patents in 2001, to outperforming the rest by producing 837,897 PCT patents in 2014. South Korea and Germany are also among the performing countries, producing comparable levels of PCT patents as each other. Nonetheless, the production capacity seems to be lagging significantly behind that of the USA and Japan. China has outperformed South Korea and Germany since 2008, and the increasing gap in production is evident.

Table 11.2 List of Registered Geographical Indications

No.	Geographical Indication	No.	Geographical Indication
1	Sarawak Pepper	30	Terengganu Songket
2	Sabah Tea	31	Kain Songket Melaka
3	Borneo Virgin Coconut Oil	32	Isau Sarawak
4	Tenom Coffee	33	Durian Nyekak Sarawak
5	Sabah Seaweed	34	Ikan Terubok Mulut Besar Sarawak
6	Bario Rice	35	Bentong Ginger
7	Buah Limau Bali Sungai Gedung	36	Keningau Cinnamon
8	Pisco	37	Tuhau Tambunan
9	Scotch Whisky	38	Sabah Batik
10	Sarawak Beras Biris	39	Kelarai, Ulu Tomani Tenom
11	Sarawak Beras Bajong	40	Batik Terengganu
12	Kuih Lidah Kampung Berundong Papar	41	Tembaga Ladang
13	Tambunan Ginger	42	Ukiran Kayu Besut
14	Sarawak Sour Eggplant	43	Keropok Losong
15	Sarawak Layered Cake	44	Keropok Lekor Terengganu
16	Sarawak Dabai	45	Pulau Duyong Boat
17	Cognac	46	Nasi Dagang Terengganu
18	Parmigiano-Reggiano	47	Malaysia Durian Musang King
19	Langkawi Cheese	48	Belacan Sibuti
20	Sarawak Litsea	49	Buah Tarap, Sibuti (Buah Lomak)
21	Perlis Harumanis Mango	50	Daun Sabong, Sibuti (Daun Bagok)
22	Champagne	51	Timun Dayak Sibuti
23	Belacan Bintulu	52	Sarawak Midin
24	Sesar Unjur Sarawak	53	Kuih Cincin Kampung Melugus Papar
25	Umai Sarawak	54	Barolo
26	Tenun Pahang Diraja	55	Tequila
27	Biskut Dan San Sungai Lembing	56	Balung Lemongrass Tea
28	Kacang Goreng Sempalit	57	Ikan Empurau Sarawak
29	Gaharu Gopeng	58	Ikan Puput Sarawak

Source : MyIPO, 2016

Table 11.3 Total Patent Applications in the Top Five Countries, 2001 - 2014

Year	Japan	USA	China	South Korea	Germany
2001	506,643	290,921	31,233	88,325	137,741
2002	483,809	291,935	41,420	94,252	132,844
2003	484,943	301,849	58,757	112,754	134,643
2004	510,027	330,950	69,018	136,441	146,062
2005	530,009	383,367	97,952	162,698	153,659
2006	517,494	404,406	129,292	173,301	160,628
2007	508,276	437,481	161,313	176,336	163,797
2008	510,005	429,000	204,275	173,496	171,851
2009	463,610	398,038	241,437	170,233	162,345
2010	468,417	433,199	308,326	178,654	173,619
2011	475,051	440,632	436,170	187,747	175,606
2012	490,271	473,489	561,408	203,836	183,048
2013	473,158	501,280	734,114	223,532	184,523
2014	465,987	509,622	837,897	230,556	179,535

Source : WIPO IP Statistics Data Centre, 2016

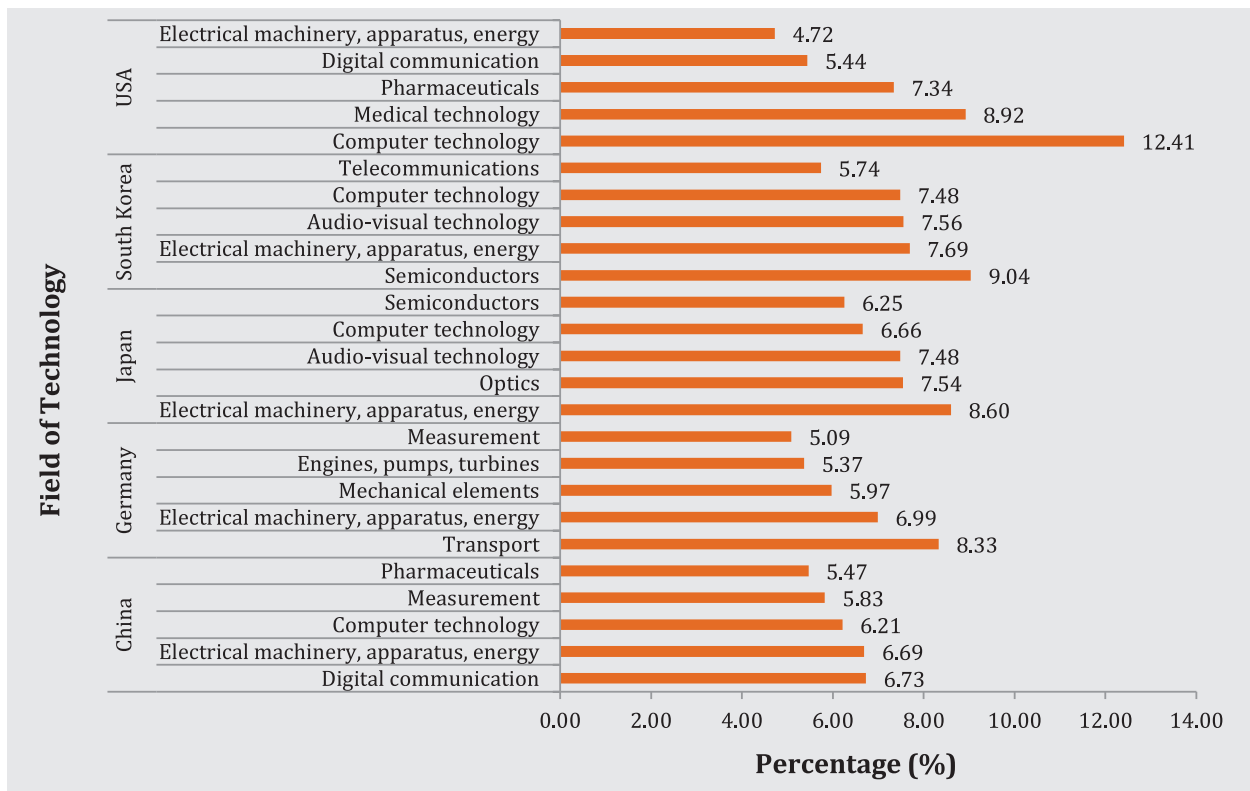
11.7.2 Top Patent Applications by Fields of Technology

Figure 11.18 presents the share of patent applications (top five) by fields of technology. The prominent fields of technology of each country seem to correspond to the competitive advantage of their respective economies. The USA performed in Computer Technology; South Korea in Semiconductor; Japan in Electrical Machinery, Apparatus, Energy; Germany in Transport; and China in Digital Communication.

11.7.3 Performing Middle-Income Countries

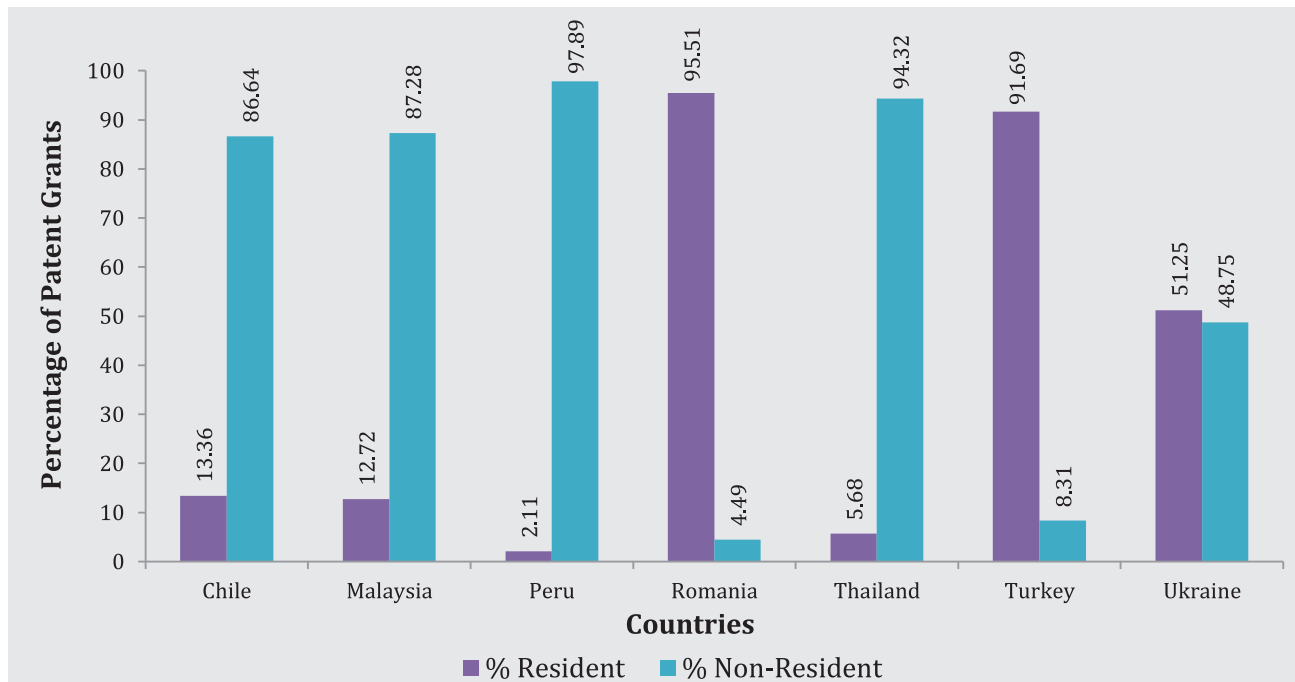
Figure 11.19 compares the share of patents granted to residents with that of non-residents in selected middle-income countries. There is a large gap between the share of the residents and the non-residents in almost all selected countries. Chile, Malaysia, Peru and Thailand witnessed the dominance of non-resident patents in their economies, while conversely Romania and Turkey witnessed the dominance of the resident patents granted. The dominance of non-residents in some countries can be attributed to the strong presence of multinationals in manufacturing operations in their economies. Ukraine is a country that witnessed a relatively balanced share of patents between residents and non-residents.

Figure 11.18 Patent Applications by Fields of Technology, 2001 - 2014



Source : WIPO IP Statistics Data Centre, 2016

Figure 11.19 Patent Grants by Residency, Selected Middle-Income Countries, 2014

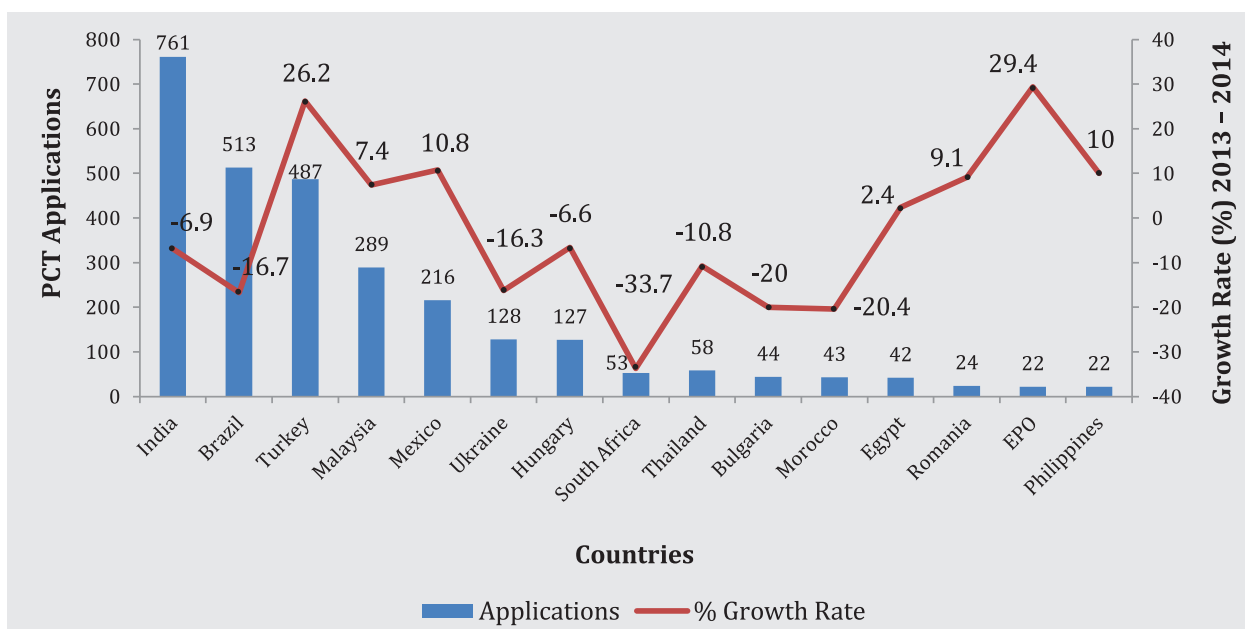


Source : WIPO IP Statistics Data Centre, 2016

11.7.4 Global Trends in PCT Applications

The performance of Malaysia in PCT applications has been highlighted in WIPO Reports²⁸. Figure 11.20 shows PCT applications for selected offices of middle-income countries. Malaysia has emerged as one of the performing countries in PCT applications. It has outperformed many comparable middle-income economies such as Mexico, Hungary, South Africa and Thailand. Malaysia’s inventors seek patent protections in both advanced (e.g. USA and Europe) and emerging (e.g. China and Indonesia) economies. Similar attempts by other middle-income countries is evident (Table 11.4).

Figure 11.20 PCT Applications, Selected Offices of Middle-Income Countries, 2014



Note : EPO – Eurasian Patent Organisation
 Source : WIPO PCT Yearly Review, 2015

Table 11.5 lists the top performing universities in terms of PCT applications. Universities in the USA emerged to dominate the top 50 universities’ patents landscape. Seoul National University of South Korea, Nanyang Technological University of Singapore, Kyoto University and University of Tokyo of Japan, Korea University of South Korea, and Peking University of China stand out among the Asian countries as being in the top 20 performing universities. Table 11.6 lists the top government and research institutes in performing PCT applications. It is noteworthy that MIMOS Berhad of Malaysia is listed as one of the top institutes in the world, performing at level comparable to that of the top ten institutes.

²⁸ WIPO (2015) PCT Yearly Review.

Table 11.4 PCT National Entries, Top 20 Offices, 2013

Office	Brazil	Cuba	Hungary	India	Malaysia	Mexico	South Africa	Thailand	Turkey	Ukraine	Others	Total
USA	356	22	150	1176	130	106	235	29	96	37	244	2,581
European Patent Office	150	8	61	452	34	51	94	10	240	23	114	1,237
China	85	8	26	243	37	34	62	12	73	9	130	719
Thailand	8	4	4	96	26	2	1	538	0	0	4	683
Japan	79	7	19	222	23	20	34	11	32	7	57	511
Brazil	129	7	16	142	18	47	46	3	11	4	43	466
India	45	6	19	172	28	17	67	12	13	9	65	453
Australia	35	7	13	167	28	10	75	9	14	1	52	411
Canada	39	8	15	152	10	42	50	1	12	7	54	390
Republic of Korea	51	8	11	156	21	22	22	8	21	6	44	370
South Africa	21	9	7	78	5	6	158	2	7	1	23	317
Mexico	53	8	12	101	7	50	15	1	6	4	38	295
Russian Federation	25	6	17	61	3	14	29	3	18	18	21	215
Indonesia	18	2	7	74	43	6	19	7	1	2	26	205
Malaysia	8	5	3	76	32	4	18	5	0	0	19	170
Singapore	20	4	2	72	17	2	12	4	1	1	16	151
New Zealand	7	1	8	59	7	3	26	1	2	1	9	124
Colombia	21	4	0	23	9	24	6	1	0	2	23	113
ARIPO	2	1	1	45	4	0	44	1	1	2	11	112
Eurasian Patent Organisation	4	1	14	33	2	6	5	0	12	5	19	101

Note : ARIPO - African Regional Intellectual Property Organisation
Source : WIPO PCT Yearly Review 2015

Table 11.5 Top 50 PCT Applicants, Universities, 2014

No	Applicants	Origin	Applications
1	University of California	USA	413
2	Massachusetts Institute of Technology	USA	234
3	University of Texas System	USA	154
4	Harvard University	USA	147
5	Johns Hopkins University	USA	135
6	Leland Stanford Junior University	USA	113
7	Columbia University	USA	112
8	California Institute of Technology	USA	103
9	University of Pennsylvania	USA	94
10	Seoul National University	South Korea	92
11	Cornell University	USA	87
12	Nanyang Technological University	Singapore	82
13	University of Florida	USA	81
14	Kyoto University	Japan	81
15	Danmarks Tekniske Universitet	Denmark	81
16	University of Tokyo	Japan	79
17	University of Michigan	USA	78
18	Korea University	South Korea	77
19	Peking University	China	76
20	University of Washington	USA	74
21	ISIS Innovation Limited	UK	74
22	Kyushu University	Japan	72
23	Tsinghua University	China	70
24	Korea Advanced Institute of S & T	South Korea	67
25	Osaka University	Japan	62
26	University of North Carolina	USA	59
27	Postech Foundation	South Korea	57
28	University of Illinois	USA	57
29	National University of Singapore	Singapore	56
30	Yonsei University	South Korea	56
31	Tohoku University	Japan	55
32	Hanyang University	South Korea	54
33	Duke University	USA	51
34	New York University	USA	51
35	Eidgenossische Technische Hochschule Zurich	Switzerland	50
36	Kyungpook National University	South Korea	48
37	Ecole Polytechnique Federale de Lausanne	Switzerland	45
38	Northeastern University	USA	44
39	China University of Mining and Technology	China	44
40	Emory University	USA	44
41	University of Utah	USA	44
42	University of Minnesota	USA	43
43	University of Southern California	USA	41
44	University of Pittsburgh	USA	41
45	Imperial Innovations Ltd	UK	41
46	State University of New York	USA	41
47	University of Rochester	USA	40
48	Yeda Research and Development Co Ltd	Israel	39
49	University of Houston	USA	38
50	Northwestern University	USA	38

Source : WIPO PCT Yearly Review 2015

Table 11.6 Top 30 PCT Applicants, Government and Research Institutes, 2014

No	Applicants	Origin	Applications
1	Commissariat A L'energie Atomique et Aux Energies Alternatives	France	434
2	Fraunhofer-Gesellschaft zur Forderung der Angewandten Foshung EV	Germany	318
3	China Academy of Telecommunications Technology	China	196
4	Institute of Microelectronics of Chinese Academy of Sciences	China	156
5	Agency for Science, Technology and Research	Singapore	152
6	Centre National de la Recherche Scientifique (CNRS)	France	150
7	Institut National de la Sante et de la Recherche Medicale (INSERM)	France	136
8	MIMOS Berhad	Malaysia	119
9	Council of Scientific and Industrial Research	India	117
10	National Institute of Advanced Industrial Science and Technology	Japan	114
11	Consejo Superior de Investigaciones Cientificas (CSIC)	Spain	90
12	USA Represented by the Secretary Dept of Health and Human Services	USA	82
13	Korea Institute of Energy Research	South Korea	81
14	Nederlandse Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek TNO	Netherlands	66
15	Korea Institute of Industrial Technology	South Korea	63
16	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Australia	38
17	Mayo Foundation for Medical Education and Research	USA	38
18	Korea Institute of Machinery & Materials	South Korea	36
19	RIKEN (The Institute of Physical and Chemical Research)	Japan	36
20	Consiglio Nazionale delle Richerche	Italy	34
21	Korea Research Institute of Bioscience and Biotechnology	South Korea	34
22	Electronics & Telecommunications Research Institute of Korea	South Korea	55
23	Cleveland Clinic Foundation	USA	53
24	Sloan-Kettering Institute for Cancer Research	USA	48
25	Korea Research Institute of Chemical Technology	South Korea	47
26	Max-Planck-Gesellschaft zur Forderung der Wissenschaften EV	Germany	43
27	United States of America represented by the Secretary of the Navy	USA	42
28	Korea Electronics Technology Institute	South Korea	62
29	Battelle Memorial Institute	USA	60
30	Japan Science and Technology Agency	Japan	55

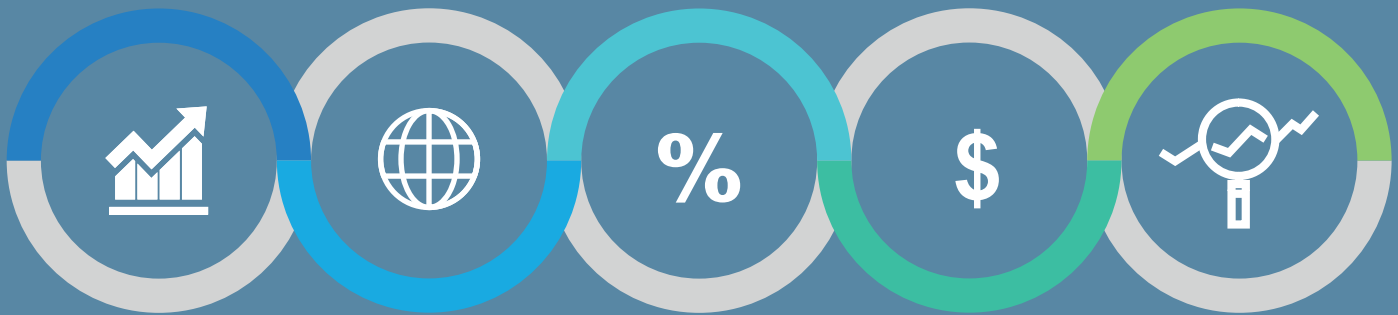
Source : WIPO PCT Yearly Review 2015

11.8 Summary

Malaysia has made progress in IPR applications that have led to technological development. Foreign multinationals and inventors have also shown interest in securing their IP protection in Malaysia. Nonetheless, only a few local organisations stand out in performing patenting activities and seeking commercialisation of their inventions in the international market via PCT patents. MIMOS stands out to be one of the top research institutions in the world in terms of patent applications in PCT. Malaysia's progress in patenting activities has been encouraging when compared to the performance of the selected middle-income countries in the world.



Commercialisation and Returns on R&D Investment



Since 2005

Malaysia experience deficit in the royalties and licensing fees

2010 – 2015

MIMOS technologies amounted to **RM18.88 billion**

Monetisation of technologies amounted to **RM1.23 billion**

Commercialisation of IPR (2012)

PRIs and Universities **RM1.62m**

Business Enterprises **RM15.41m**

Between 2007 & 2013
Income generation by
the public universities



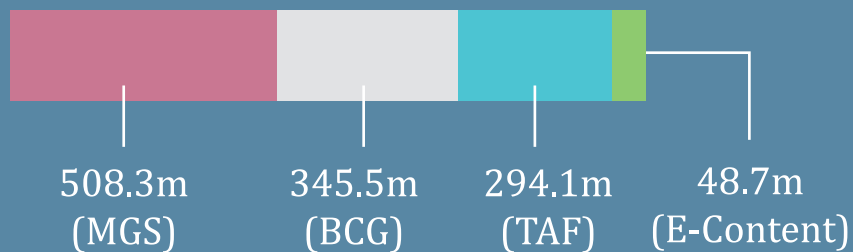
▶▶ CHAPTER 12

Commercialisation Rate

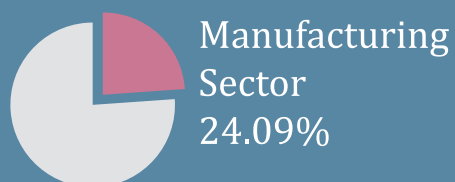
6–7 th MP	5.1%
8 th MP	3.4%
9 th MP	8.0%

CRDF contributes RM1,211.7m in sales.

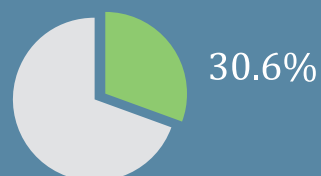
Other funds:



Firms that Generate Sales from IPRs



Rate of Commercialisation in MPOB





CHAPTER 12: COMMERCIALISATION AND RETURNS ON R&D INVESTMENT

12.1 Introduction

The chapter captures the commercialisation efforts of the public and private sectors, and estimates the returns on R&D investment in selected sectors where the data is available. There is no one standard definition of 'commercialisation' adopted in the report, given that commercialisation is defined in various ways by respective ministries and agencies. How much can be commercialised also depends on the time frame applied to a project. It is important to realise that capturing commercialisation efforts requires monitoring and tracking of the research projects even after grant expiry periods. Past studies show that commercialisation globally takes an average of at least 8 years to materialise. This chapter only captures short term outcomes of commercialisation in terms of number of products commercialised and revenue generated from the sales of such commercialisation. Broadly speaking, invention disclosures, patent applications and patents granted are considered potential commercialisation. In this regard, Malaysia experienced an increasing trend of patenting. Nevertheless, foreign applications remain higher than local applications. MIMOS has been one of the top performing institutions that has significant patent applications. Besides quantitatively capturing the efforts of commercialisation, it is also important to provide illustrations of successful commercialisation efforts in order to provide adequate evidence of the potential nature of commercialisation efforts. Therefore in this chapter, successful cases of commercialisation have been also illustrated.

12.2 Commercialisation Landscape in Malaysia

The progress of S&T in Malaysia went through different phases. The First National Science and Technology Policy (NSTP1) was formulated in 1986 to achieve continuous scientific and technological development, and especially to accelerate economic growth, industrial development and creation of a high-tech (advanced) society. Consequently, a National Action Plan for Industrial Technology Development was launched in 1991 to specifically promote industrial technological development. Serious efforts in commercialisation began from the 6th Malaysia Plan (1991 – 1995), where emphasis was made to ensure that public R&D programmes became more market oriented by exploiting the commercialisation of research and technology. The 7th, 8th and 9th Malaysia Plan subsequently continued these efforts. Increasing attention was also placed on the private sector. The government introduced various types of incentives to encourage private sector involvement in R&D activities. In addition, in order to intensify commercialisation of research results, the government implemented various measures such as setting up institutions and providing incentives and commercialisation grants. In the 9th Malaysia Plan, a special funding for the biotechnology industry was established to promote commercialisation of biotechnology products. Greater emphasis was also given in the 10th Malaysia Plan and 11th Malaysia Plan, where innovation was seen as an important element in the economic system. The 10th Malaysia Plan emphasised the need to strengthen the enabling environment – i.e. creating opportunities by providing incentives and investment opportunities, including public procurement – as well as increasing the funds for research, development and commercialisation activities. The current plan, 11th Malaysia Plan emphasises strengthening the governance mechanisms, enhancing demand-driven research, strengthening industry-academia collaboration, and promoting private financing of research, development, commercialisation and innovation.

Table 12.1 shows the rate of commercialisation of the publicly funded R&D projects in Malaysia during the various Malaysia plans. The rate is calculated based on the number of projects that were successfully commercialised. The commercialisation rate of the largest funding system for public R&D was 5.1% during the 6th and 7th Malaysia Plan. This was the commercialisation outcome of the Intensification of Research in Priority Areas (IRPA) projects. In the 8th Malaysia Plan, the commercialisation rate dropped to 3.4%. More financial allocation was streamed to the commercialisation initiatives during the 9th Malaysia Plan, hence the rate of commercialisation improved to 8.0%.

Table 12.1 Commercialisation of Publicly Funded Projects

Malaysia Plan	Commercialisation Rate (%)
6 th & 7 th Malaysia Plan	5.1
8 th Malaysia Plan (2000 – 2005)	3.4
9 th Malaysia Plan (2006 – 2010)	8.0

Note : Commercialisation rate refers to the number of projects that have been commercialised (generated sales) out of the total projects during the periods.

Source : Malaysia Plan, MOSTI, 2014

Commercialisation efforts of the projects awarded in 9th Malaysia Plan highlight that some of the approved projects were successfully commercialised, thereby generating significant income. These programmes received different allocations and approved different numbers of projects. CRDF contributed RM1,211.7 million in sales, while the sales generated by MGS, BCG and TAF were RM508.3 million, RM345.5 million and RM294.1 million respectively (Table 12.2).

Table 12.2 Commercialisation by Types of Funds

Funding Stage	Projects Approved	Commercialised Projects	Sales Generated (RM Million)
Creation			
Pre Seed	334	12	10.1
Pre-Commercialisation			
DAGS	26	2	1.6
E-Content	97	40	48.7
MGS	70	60	508.3
Commercialisation			
BCG	81	64	345.5
CRDF	154	129	1,211.7
TAF	30	21	294.1

Source : MOSTI 2014

Revenue generation through IPR is still low in Malaysia. Table 12.3 shows the sales generated in 2012 by the PRIs²⁹ and universities which was RM1.62 million, while the business enterprises generated RM15.41 million in sales. Although IP filing is low in the business enterprises (464), the sales generation from the IPs are much higher than PRIs and universities (7,899 IPs filed). Business enterprises success in commercialisation is much greater given their market driven research activities. It is important to foster better collaboration between industry and academia to mutually benefit from R&D activities.

Table 12.3 Commercialisation of IPRs

Sector	IPs Filed	Sales (RM Million)
Business Enterprises	464	15.41
PRIs and Universities	7,899	1.62

Note : The sales value is based on a sample surveyed in 2013

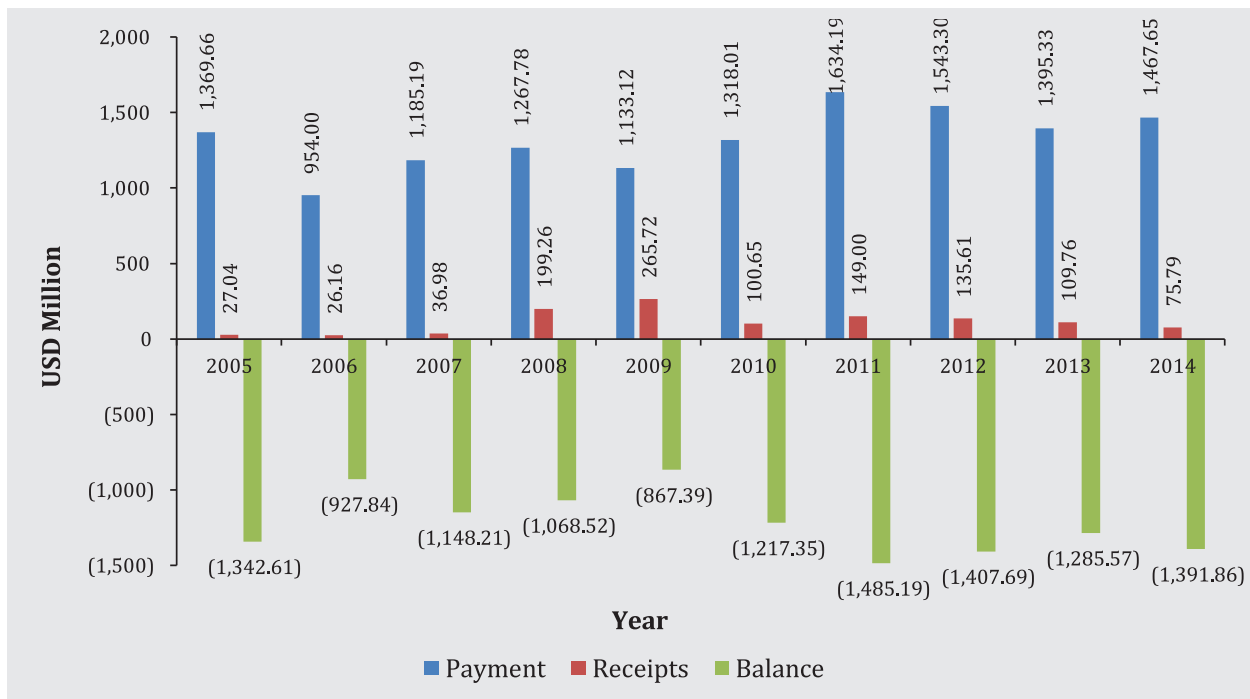
Source : MASTIC

12.3 Commercialisation of IPRs: Royalties and Licensing Fees

Malaysia's position in trade of IPRs indicates the possible returns for the trading of IPRs. Malaysia has been witnessing a deficit in royalties and licensing fees since 2005 (Figure 12.1). Payments ranged from around USD1,318 million (lowest) to USD1,634 million (highest) since 2010, while receipts has seen a decreasing trend from USD265 million (highest in the selected period of time) in 2009 to USD75 million in 2014. The trend of Malaysia's IP trading does not seem to follow the global trend which implies rather balanced IP trading (Figure 12.2). Note that there is a marginal increase in global IP trading deficit since 2011. Table 12.4 shows the charges for the use of IP as payments and receipts in top performing IP countries. The USA emerged to be the outstanding country, having more receipts of IP than payments. This is followed by Japan, while Germany witnessed a moderate pace of increase in its IP fees trade balance. South Korea witnessed a rather stable IP fees trade deficit since 2011. China records an increasing IP fees trade deficit. The USA has the highest positive net trade balance, followed by Japan and Germany (Table 12.5).

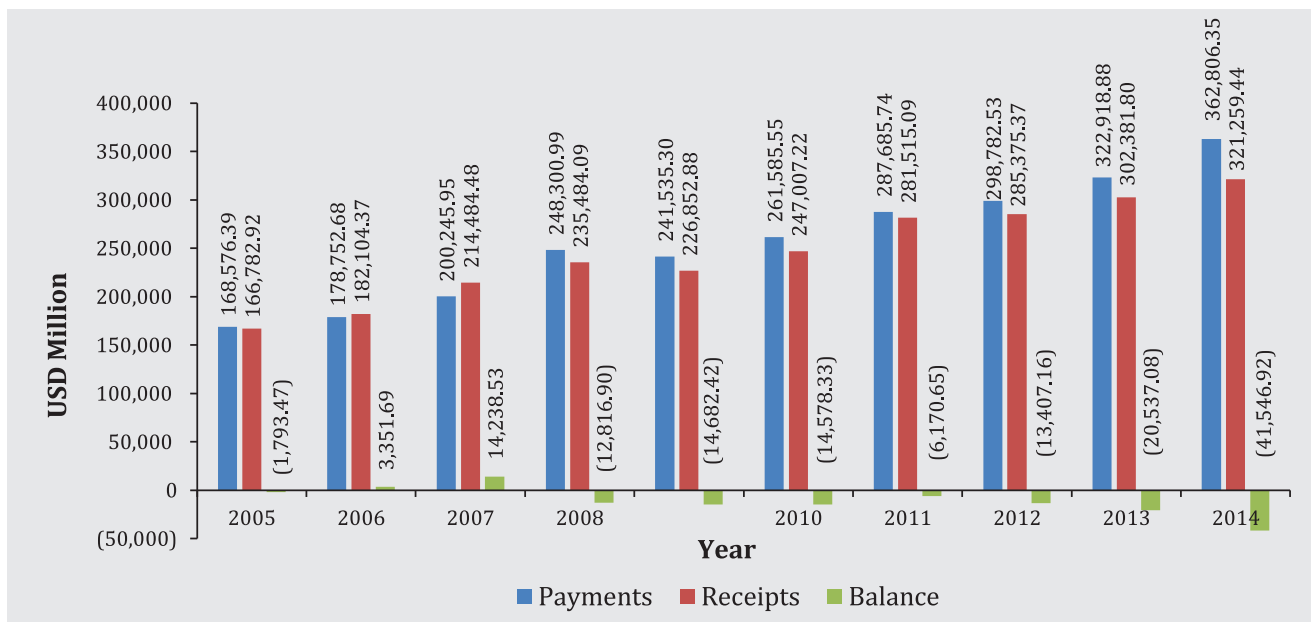
²⁹ In this chapter PRIs specifically refers to the Government Research Institutes.

Figure 12.1 Royalties and Licensing Fees, Malaysia



Source : World Bank, 2016

Figure 12.2 Global Receipts, Payments and Balance of Trade in IP



Source : World Bank, 2016

Table 12.4 IP as Payments and Receipts, Top 5 Countries

Country	2012		2013		2014	
	Receipts (USD)	Payments (USD)	Receipts (USD)	Payments (USD)	Receipts (USD)	Payments (USD)
China	1,044,102	17,748,983	886,670	21,033,078	676,382	22,613,801
Germany	10,261,881	6,377,289	13,113,826	8,424,539	13,797,146	8,122,213
Japan	31,892,292	19,897,558	3,1586,957	17,831,143	36,832,563	20,934,966
South Korea	3,902,900	8,616,600	4,328,100	9,836,800	5,167,100	10,546,000
USA	124,439,000	38,660	127,927,000	38,999	130,361,000	42,124

Source : World Bank, 2016

Table 12.5 Trade Balance in IP, Top Five Countries, USD

Country	2005	2009	2010	2011	2012	2013	2014
China	-5,163,852	-10,635,818	-12,209,062	-13,962,806	-16,704,881	-20,146,408	-21,937,418
Germany	-1,461,430	204,739	1,161,342	3,316,999	3,884,591	4,689,286	5,674,932
Japan	3,001,768	48,63,307	7,911,669	9,816,532	11,994,733	13,755,814	15,897,596
South Korea	-2,684,400	-4,100,200	-5,994,500	-3,016,000	-4,713,700	-5,508,700	-5,378,900
USA	48,871,000	67,109,000	74,971,000	87,246,000	85,779,000	88,928,000	88,237,000

Source : World Bank, 2016

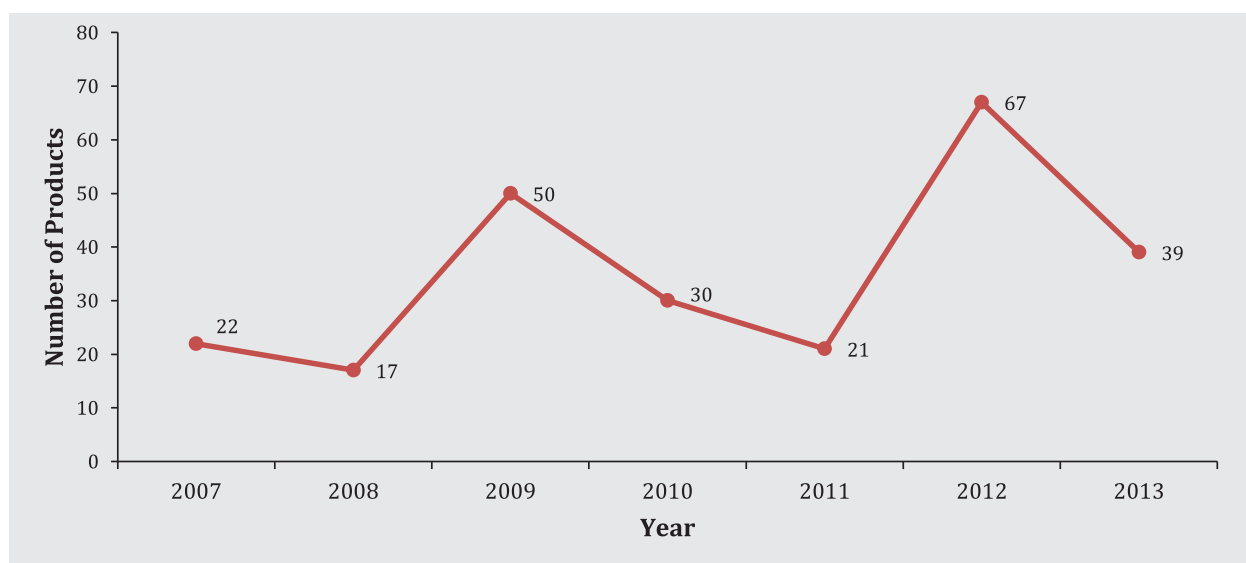
12.4 Commercialisation at Institutional and Organisational Level

This section discusses the commercialisation efforts by the universities, PRIs and business enterprises. Various data points were used to extract information on commercialisation. Given that commercialisation is a long-term effort, it is the norm that success is not only captured in terms of sales generation, but also in terms of start-ups and spin-off companies that have started businesses – together with their progress and success cases.

12.4.1 Public Universities

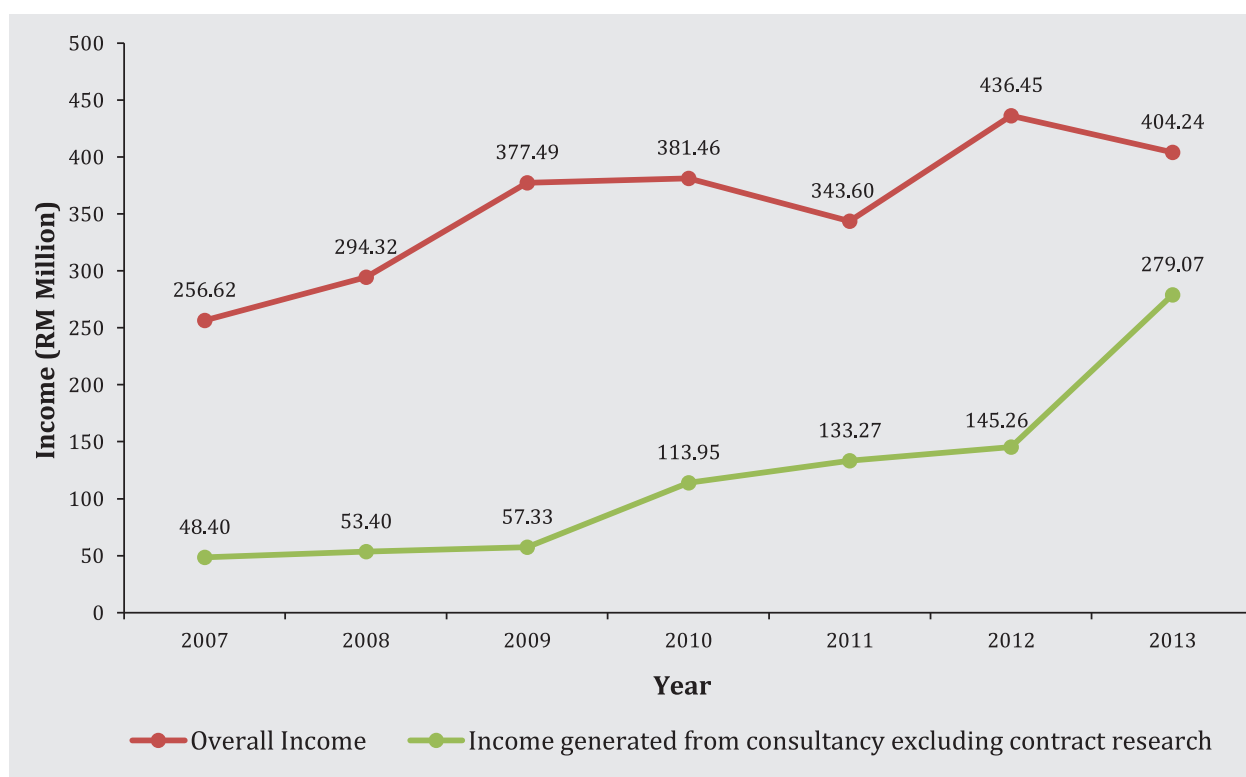
The public universities in Malaysia have embarked on the third mission of the university agenda, namely generating revenue to complement their revenue stream. In this effort, the technology transfer units were established and universities embarked on commercialisation initiatives. Figure 12.3 and Figure 12.4 show the total number of products licensed by the public universities as well as the income generated by the public universities. The number of commercialised products was in the range of 17 to 67 over the period of 2007 – 2013 (Figure 12.3). Income generated by the public universities increased twofold between 2007 and 2013, from RM256.62 million to RM404.24 million (Figure 12.4). Nevertheless, both products licensed as well as income generated are relatively low in absolute numbers and values. Efforts need to be strengthened in order to improve the commercialisation capability of the public universities, given that a larger portion of the R&D resources reside in the universities.

Figure 12.3 Total Number of Products Licensed, Public Universities



Note : Based on 20 public universities
 Source : MOHE, 2016

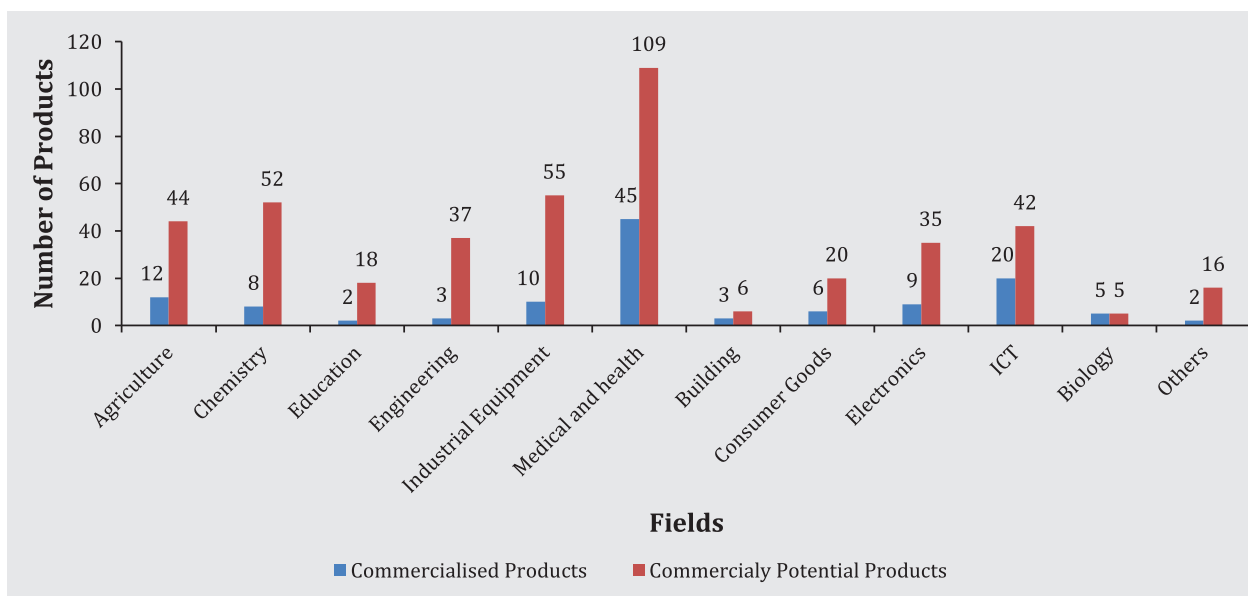
Figure 12.4 Income Generated by Public Universities



Note : Based on 20 public universities. Overall income includes income generated from training courses (non-degree programme) / postgraduate fees (leading to higher degree) / franchise programme fees / hospital recoupable fees / technology licensing / commercialised products.
 Source : MOHE, 2016

Commercialisation of the public universities by field of research indicates that universities are more successful in the fields such as medical and health, ICT, and agriculture (Figure 12.5). It signals that two necessary conditions should exist for the commercialisation to materialise. Since there is a better internal market support demand in the medical field, researchers and scientists were more successful in commercialising in the medical and health fields. Likewise, due to the comparative advantages in certain agriculture sectors and adequate local knowledge, commercialisation was more successful there as well. The strong presence of ICT industry that features higher R&D intensity and significant government support has contributed to the success of commercialisation in ICT. On the other hand, weak industrial structure along with lack of R&D activities in other fields limit university-industry collaboration, contributing to the low commercialisation.

Figure 12.5 Number of Products Commercialised by Fields, 2011



Source : MOHE, 2011

Table 12.6 shows the outcome of research activities of the 13 public universities and 17 private universities surveyed by MASTIC in 2015. Income generated from technology transfers amounts to RM175 million, while sales from licenses, options and assignments (LOAs) amounts to RM11 million. A total of 76 spin-off companies were established. The invention disclosures and patent filings by these institutions are impressive, especially by public universities. Nevertheless, the commercialisation of IPRs is still low.

Table 12.6 IPRs and Commercialisation of Public and Private Universities

IPR/Commercialisation	Public Universities	Private Universities	Total
Invention disclosures	4,405	9	4,414
Patents filed	2,652	32	2,684
Patents granted	454	9	463
No. of licenses/ options/ assignments (LOAs)	388	2	390
Spin-off / Spin-out companies established	75	1	76
Technology transfer income (RM Million)**	171.04	3.98	175.02
Sales revenue from LOAs (RM Million)	11.03	-	11.03
Expenditure for commercialisation activities (RM Million)	62.25	-	62.25

Note : Based on data availability of 13 public universities and 17 private universities. **Technology transfer consists of: (1) Research collaboration; (2) Contract research; (3) Sales of services/trainings; (4) Sales of data & software; (5) Consultancy.

Source : MASTIC, 2016

12.4.2 Business Enterprises

Based on the innovation survey 2015, the total sales value generated by Business Enterprises from patents and industrial designs was computed. Total sales generated by commercialising IPR was RM1.899 billion in 2015 (Table 12.7). The manufacturing sector generated the largest sales amounting to RM1.621 billion, while the services sector sales through commercialisation amounts to RM0.277 billion. The average return of sales from commercialisation are 10.59% and 3.57% for the manufacturing and services sectors respectively. Nearly 24% of the firms in manufacturing and 11.6% of the firms from services sectors were able to generate sales from their IPRs.

Table 12.7 Sales Generated from Commercialising IPRs, 2015

Commercialisation	Manufacturing	Services	All Sectors
Total sales generated from commercialisation (RM Billion)	1.621	0.277	1.899
Average return of sales from commercialisation (%)	10.59	3.567	6.28
Companies successful in generating sales from IPR (%)	24.09	11.57	16.41

Note : Commercialisation refers to sales generated from patents / industrial designs. Average return of sales refers to average percentage of sales from commercialisation out of total sales.

Source : National Survey of Innovation 2015

Table 12.8 compares the average sales and sales growth between the firms which undertake R&D and those which do not. In general, firms undertaking R&D have higher average sales, and the differences in sales indicate better growth prospects.

Comparing the growth of the firms between 2012 and 2014 indicates that the average growth of firms with R&D activities is 3%, while firms without R&D activities have significant negative growth. The evidence seems to suggest that R&D matters for sales and sales growth.

Table 12.8 Comparing Sales Between Firms with and without R&D Activities

Firm Sales	With R&D	Without R&D
Average Sales (RM Million)	109.1	0.55
Difference in Sales (Average) (RM Million)*	76,767,818	11,939,987
Average Growth in Sales (%) **	3	-14.76

Note : *Differences in sales between 2014 and 2012. **Average growth between 2014 and 2012.

Source : National Survey of Innovation 2015

12.4.3 Public Research Institutions

Table 12.9 shows the IPRs and commercialisation activities of the 21 PRIs. PRIs in total have disclosed 2,228 inventions and filed 1,223 patents, with granted patents of 263. Commercialisation income generated through technology transfer and sales from licenses, options and assignments (LOAs) amounts to RM104.51 million. Technology transfer in the form of research collaboration, contract research, sales of services/trainings, sales of data, and software and consultancy remain higher than revenue from LOAs.

Table 12.9 IPR and Commercialisation of Public Research Institutions

IPR/Commercialisation	PRIs
Invention disclosures	2,228
Patents filed	1,223
Patents granted	263
Number of licenses / options / assignments (LOAs)	261
Spin-off / Spin-out companies established	10
Technology transfer income (RM Million)*	99.84
Sale revenue from LOAs (RM Million)	4.67
Expenditure for commercialisation activities (RM Million)	44.66

Note : Based on data availability of 21 PRIs. *Technology transfer consists of: (1) Research collaboration; (2) Contract research; (3) Sales of services/trainings; (4) Sale of data & software; (5) Consultancy.

Source : MASTIC, 2016

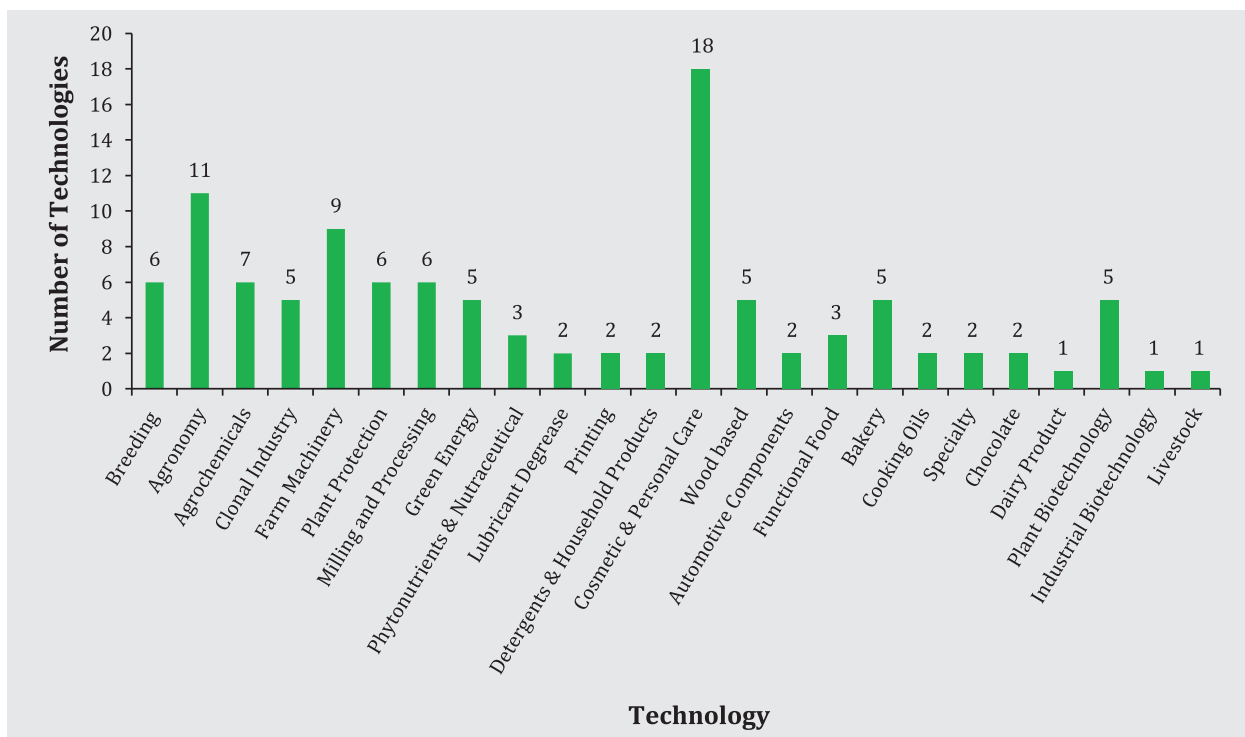
PRIs have also striven to improve their commercialisation efforts. Selected success cases of PRIs are highlighted in this section to provide some illustration of the commercialisation initiatives and outcomes.

12.4.3.1 Malaysian Palm Oil Board

Over the past 10 years, the Malaysian Palm Oil Board (MPOB) has created a market value of RM2.04 billion by commercialising its technologies (Damodaran, 2010). Currently, MPOB’s commercialisation rate stands at 30.6%, being the highest in the country compared with other institutions (Damodaran, 2010; MPOC, 2016). The close collaboration with industry is key for improving the success of its commercialisation efforts. Products such as red palm oil; palm tocotrienol; fertiliser; planting material; biological and oleochemical based pesticides; cosmetics; soap; and plant/machinery/equipment like the continuous steriliser, Rolek nut cracker, Grabber (mechanical fresh fruit bunch loader), and Cantas (mechanical harvester) have been commercialised by MPOB. Figure 12.6 shows the number of technologies commercialised by MPOB during 1986 – 2010. A total of 111 technologies and products were commercialised by MPOB. Technologies and products with the highest number of commercialisations include cosmetic and personal care (18) as by-products of palm oil, agronomy (11), and farm machinery (9). New revenue generated from MPOB’s commercialised Food and Health based products amounts to RM22.8 million (NSRC, 2013).

Under the Palm Oil National Key Economic Area, 8 Entry Point Projects (EPPs) were identified with two strategic thrusts, namely: ensuring sustainability and productivity; and development of the downstream sectors – especially expanding the production of oleo derivatives, commercialisation of second-generation bio-fuel for power generation, and expediting the growth of food and health-based products. MPOB plays as critical role in these initiatives for the national interest, including providing supporting services, improving planting and replanting efforts, and carrying out mill certifications.

Figure 12.6 Technology Commercialisation by Fields, 1986 – 2010



Source : MPOB Annual Report

12.4.3.2 MIMOS Berhad

MIMOS Berhad (thereafter MIMOS) is one of the active institutions in patenting activities. Apart from R&D activities, MIMOS is actively engaging in commercialisation efforts. In this effort, MIMOS is involved in the creation of business/marketing funnels. The total marketing funnel created from MIMOS technologies for 2010 – 2015 amounted to RM18.88 billion, while the monetisation of technologies amounted to RM1.23 billion (Table 12.10). There is a steady increase in the marketing funnel and monetisation amount over the years except for 2015.

Table 12.10 Marketing Funnel and Monetisation

Year	Marketing Funnel (RM million)*	Monetisation (RM million)**
2010	1,009.30	0.17
2011	1,743.20	135.28
2012	1,923.00	263.38
2013	2,510.00	211.86
2014	8,090.00	401.34
2015	3,610.00	217.56
Total	18,885.50	1,229.59

Note : *Ringgit worth of potential business created from MIMOS developed technologies (based on inputs from technology recipients). **Ringgit worth of contracts awarded/purchase orders given to technology recipients by their customers.

Source : MIMOS Berhad

Apart from marketing funnel and monetisation, other key achievements of MIMOS are exhibited in Table 12.11. MIMOS has developed 108 technology components, 57 platforms, 5 frameworks, and 87 products and applications which have the potential to be incorporated as technology platforms and solutions by industries. These eventually will be the potential areas for further generation of commercialisation revenue. MIMOS managed to transfer technology to 71 technology recipients in industry. In addition, 29 end-to-end solutions were deployed to various market segments. Commercialised IPRs include 222 patents and 151 copyrights, while MIMOS is also incubating 7 companies as part of technology ventures and incubation initiatives. In order to intensify the semiconductor and microelectronics ecosystem, MIMOS has established an integrated world-class facility known as 1BigLab. Currently, 47 products are available at the pre-commercialisation stage.

Table 12.11 Key Achievements

Technologies	Number
Technology Components	108
Technology Platforms	57
Technology Frameworks	5
Product & Solution Prototypes	87
Technology Transfers	71
End-to-end Solutions	29
Patents and Incubations	
Patents filed with MyIPO	1,076
Patents filed with PCT & WIPO	789
Commercialised IPs	222 patents & 151 copyrights
Technology Incubations	7
Enabling Industry Through Technology	
Technology Platform and Product Development	47 products at pre-commercialisation stage
Shared R&D Infrastructure	
Process Tools Development	
Enabling Industry Through Services	
Prototyping Services	426 prototypes for industry and academia
Failure Analysis	177 industry users
Training, Consultation and Commercialisation	1,785 engineers/lecturers/students trained

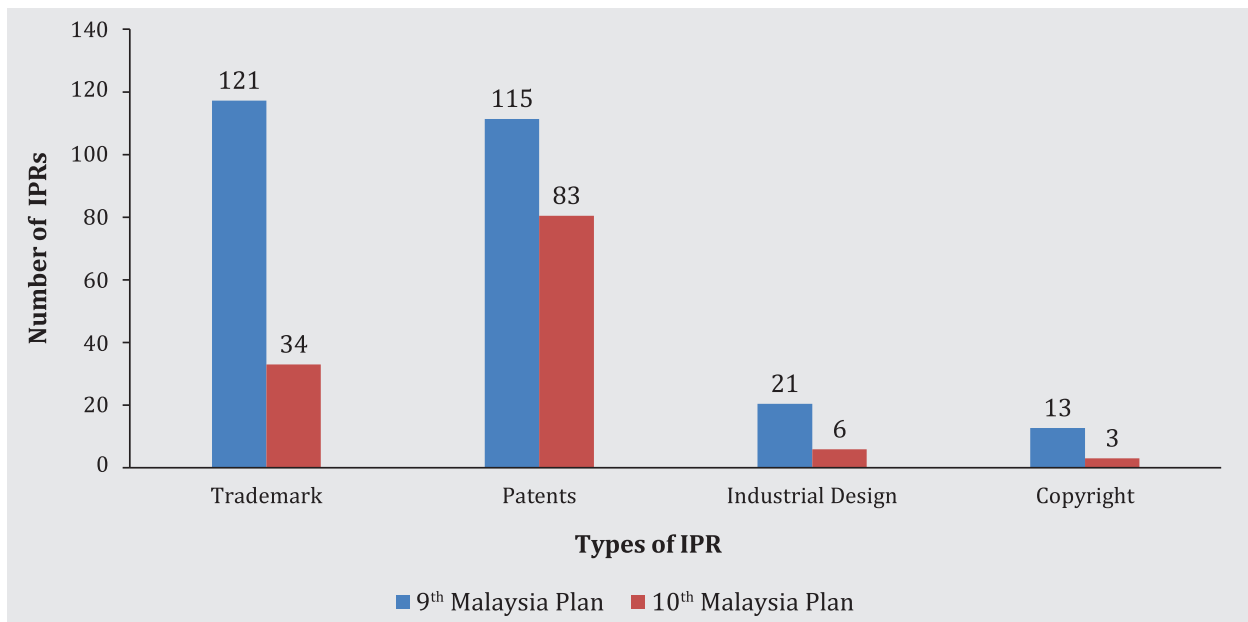
Source : MIMOS Berhad

12.5 Commercialisation at Programme Level

This section discusses some of the selected commercialisation successes of the public programmes. Some of these programmes are designed to improve the commercialisation efforts in Malaysia. This section only reports some of the selected programmes and where data is available.

12.5.1 CRDF

In line with its focus in supporting commercialisation, CRDF was established to increase the commercialisation of products, with less emphasis on publication and human resource development. In terms of IP, during 9th and 10th Malaysia Plan a total of 396 IPs were generated in various types of IPRs. CRDF recipients have generated 198 patents, 155 trademarks, 27 industrial designs, and 16 copyrights (Figure 12.7). However, only 52 of the patents were granted. In addition to IPRs, CRDF recipients also received recognition in the form of 56 international awards and 177 local awards during the 9th and 10th Malaysia Plan in total.

Figure 12.7 IPRs Generated by CRDF recipients, 9th -10th Malaysia Plan

Source : MTDC

The CRDF programme also targets to increase wealth creation & technology content of SMEs/large corporations via commercialisation of R&D done by local universities, RIs and companies. The resulting economic and wealth creation impact is shown in Table 12.12. Overall, there is a clear return of investment from the CRDF programme. At the end of the 9MP period, 128 (83%) CRDF projects were successfully commercialised. Sales generated from CRDF products amounted to RM1.39 billion, more than 6 times higher than the amount invested (RM0.23 billion). In addition, private investment has increased since 2006, with a total amount of RM418 million. Other than direct economic impact, CRDF also contributes to human capital development. During 9th Malaysia Plan, approximately 2,710 new jobs were created. A total of 1,127 knowledge workers were employed, with a breakdown of 57 PhDs, 89 Master's, 610 Degree holders and 371 Diploma holders. In addition, a number of CRDF alumni continue to act as mentors/evaluators for CRDF projects, which contributes to the success of commercialisation. Likewise, during 2011 – 2016, 58 (56%) CRDF projects were successfully commercialised and sales generation amounted to RM0.316 billion, more than 2 times higher than the amount invested (RM0.12 billion). In addition, since 2011 private investment has increased with a total amount of RM96.32 million. Approximately 1,220 new jobs were created with a total of 500 knowledge workers employed – comprising 14 PhDs, 52 Master's, 283 Degree holders and 151 Diploma holders.

Table 12.12 Commercialisation Outcomes of CRDF, 2006 – 2016

Impact Area (2006 – 2010)	Indicators
Total sales generated (RM Billion)	1.39
Total amount invested (RM Billion)	0.23
Rate of commercialisation	83% (128 out of 154 projects)
Private sector investment (RM Million)	418
Impact Area (2011 – 2016)	Indicators
Total sales generated (RM Billion)	0.316
Total amount invested (RM Billion)	0.12
Rate of commercialisation	56% (58 out of 103 projects)
Private sector investment (RM Million)	96.32

Source : MTDC

12.5.2 Business Growth Fund

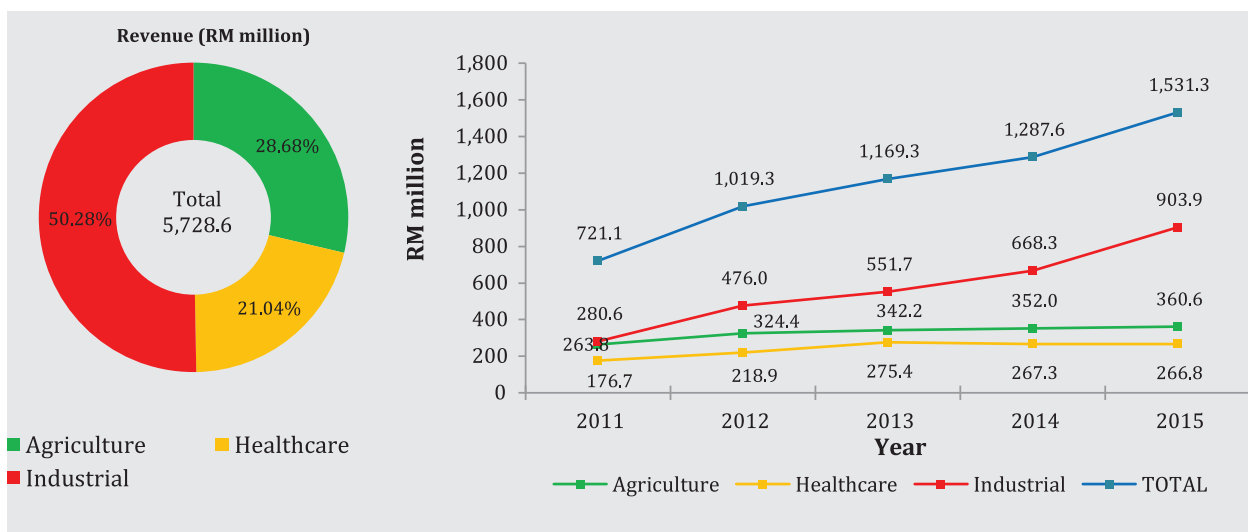
The government has established the Product Development and Commercialisation Fund (PCF) to accelerate product commercialisation. A total of 32 projects amounting to RM20.93 million were funded during 2013 – 2015. The number and amount of approved projects reached 14 and RM8.65 million respectively in 2015. The number and amount of approved projects for PCF was always in an upward trend, and a total of 29 IPs have been successfully filed during the three year period. An illustration of successful commercialisation includes the following:

- *GIANT – Big Data Analytics Solution from Fusionex Corp Sdn. Bhd.* – Fusionex is listed on the London Stock Exchange (AIM) with a market capitalisation of RM447.42 million as of 13 June 2016. Fusionex is a private sector led Big Data Analytics (BDA) Centre of Excellence in the National BDA Innovation Network. It has won awards at the Microsoft Worldwide Partner Conference (WPC) for four consecutive years (2012 – 2015). Total sales of the PCF project amounts to RM44 million indicating a high return from the investment.
- *Roaming Beamer (RB) from Reapfield Technology Sdn Bhd* – The company is listed on the Australian Securities Exchange with a market capitalisation of RM27.93 million as of 10 June 2016.
- *CORAL iFES™ (Intelligent Financial eServices System) from TESS Innovation Sdn. Bhd.* – The project won the Gold Award at the ASEAN ICT Awards 2014 on 22 January 2015 for the TESS Anti-Money Laundering (AML) solution. The total sales for the project is RM1.6 million.
- *ePMO Features Development and Enhancement from eCEOs Sdn. Bhd.* – The company was ranked 52nd in Deloitte Technology Fast 500 Asia Pacific 2013 and the total sales for the project is RM2.1 million.

12.5.3 BioNexus

The National Biotechnology Policy was instrumental in spearheading the growth of the biotechnology industry. The BioNexus Status³⁰ was recognised for qualified companies that participate in and undertake value-added biotechnology activities. The revenue growth of the BioNexus companies during 2011 – 2015 was encouraging, increasing twofold from RM721.1 million in 2011 to RM1,531.3 million in 2015 (Figure 12.8). This growth was mainly driven by the significant revenue growth in the industrial sector. Sector wise, the industrial sector's revenue growth was 222.13%, while the healthcare sector recorded a growth of 50.99% and the agriculture sector had growth of 35.69. Since 2014, the industrial sector has been contributing more than half of the total revenue of BioNexus companies (Figure 12.9).

Figure 12.8 Revenue of BioNexus Companies, 2011 – 2015

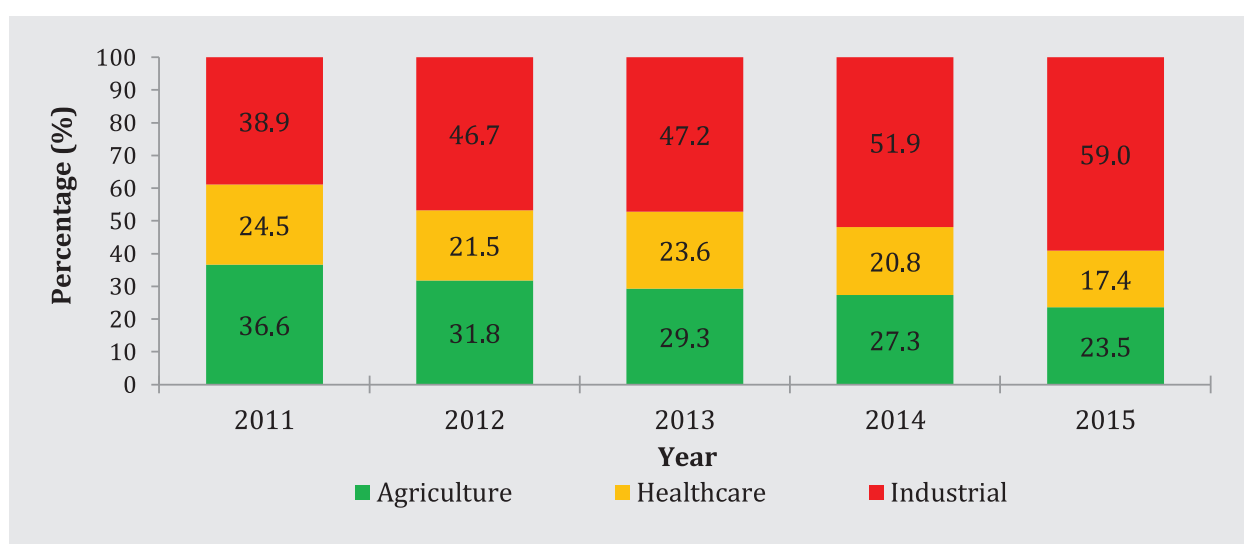


Source : BiotechCorp Malaysia

12.5.4 Creative Industry Development Fund

The Creative Industry Development Fund (CIDF) aims to facilitate and encourage Malaysian involvement in the creation, production and distribution of highly creative, original and marketable multimedia content for domestic and international markets. A total of 150 projects were approved during 2011 – 2015 with a total amount of RM76.2 million. The projects have generated sales of RM6.70 million from 2013 to 2016 (Table 12.13).

³⁰ BioNexus Status is a recognition awarded by the Government, through Malaysian Biotechnology Corporation Sdn. Bhd. (BiotechCorp) to qualified companies that participate in and undertake value-added biotechnology activities.

Figure 12.9 Revenue of BioNexus Companies by Sector, 2011 – 2015

Source : BiotechCorp Malaysia

Table 12.13 Number of Projects, Amount Approved and Commercialisation, CIDF

Year	Projects Approved (Number)	Amount Approved (RM Million)	Sales Generated from Commercialised Projects (RM Million)
2011	64	20.1	-
2012	37	19.4	-
2013	5	4.7	2.37
2014	25	15.8	2.33
2015	19	16.2	0.93
2016*	-	-	1.07
Total	150	76.2	6.70

Note : *As of 30th June 2016

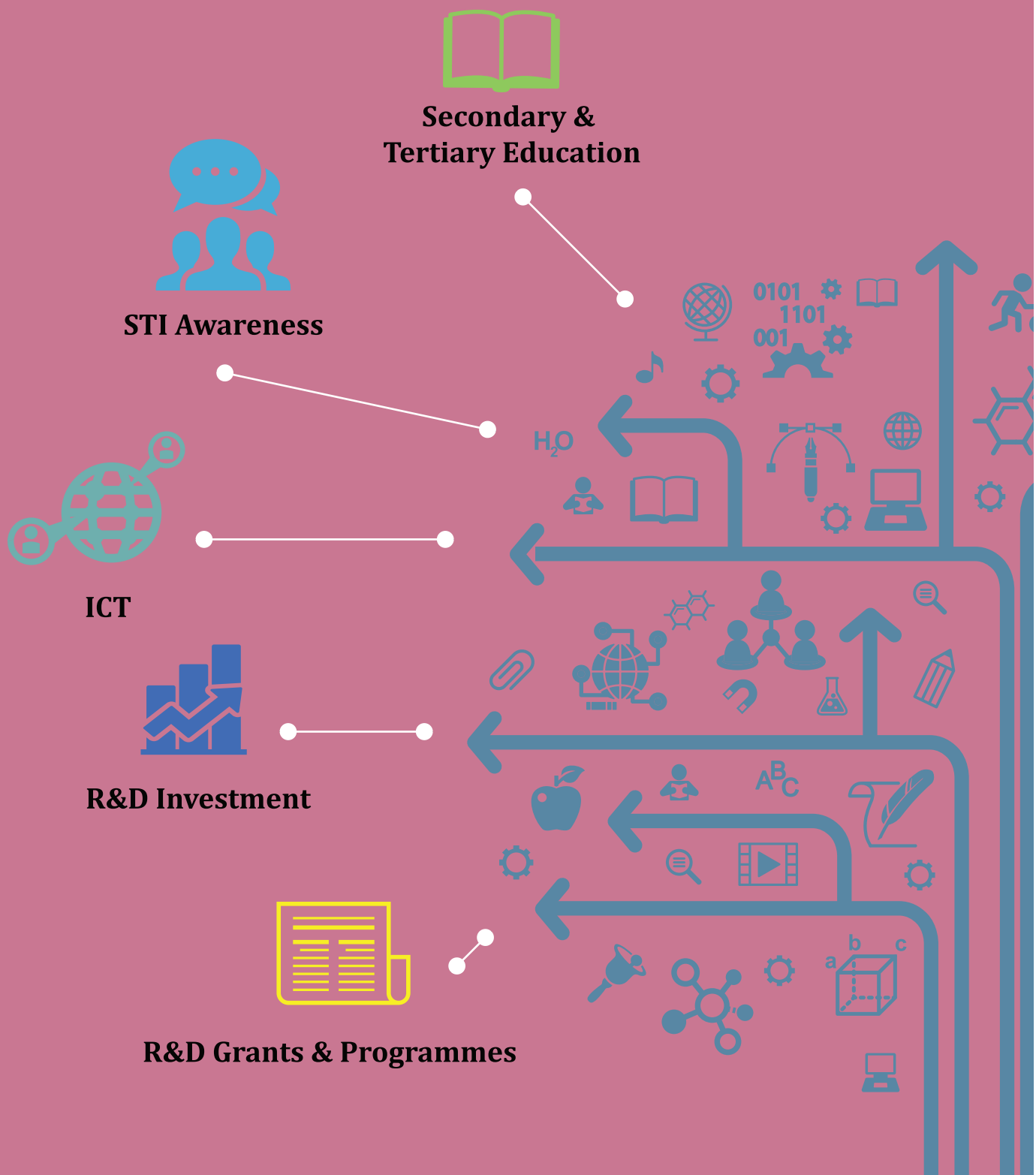
Source : Malaysian Communications and Multimedia Commission

12.6 Summary

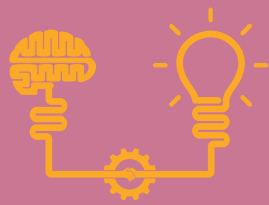
Malaysia has pursued and initiated commercialisation activities in order to spur the generation of revenue through R&D. Given the difficult nature of commercialisation, challenges remain on how to maximise the returns on R&D investment, especially in commercialising the outputs of R&D activities. Success is much better in the private sector despite still being low. Similarly, some institutions and organisations have attained better success than others. As a whole, the commercialisation activities are still low, and more efforts are needed to intensify the income generation activities through commercialisation of IPRs.



Concluding Remarks and Way Forward



▶▶ CHAPTER 13



Innovation



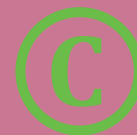
**Knowledge &
High Tech Sectors**



**Energy &
Green Technology**



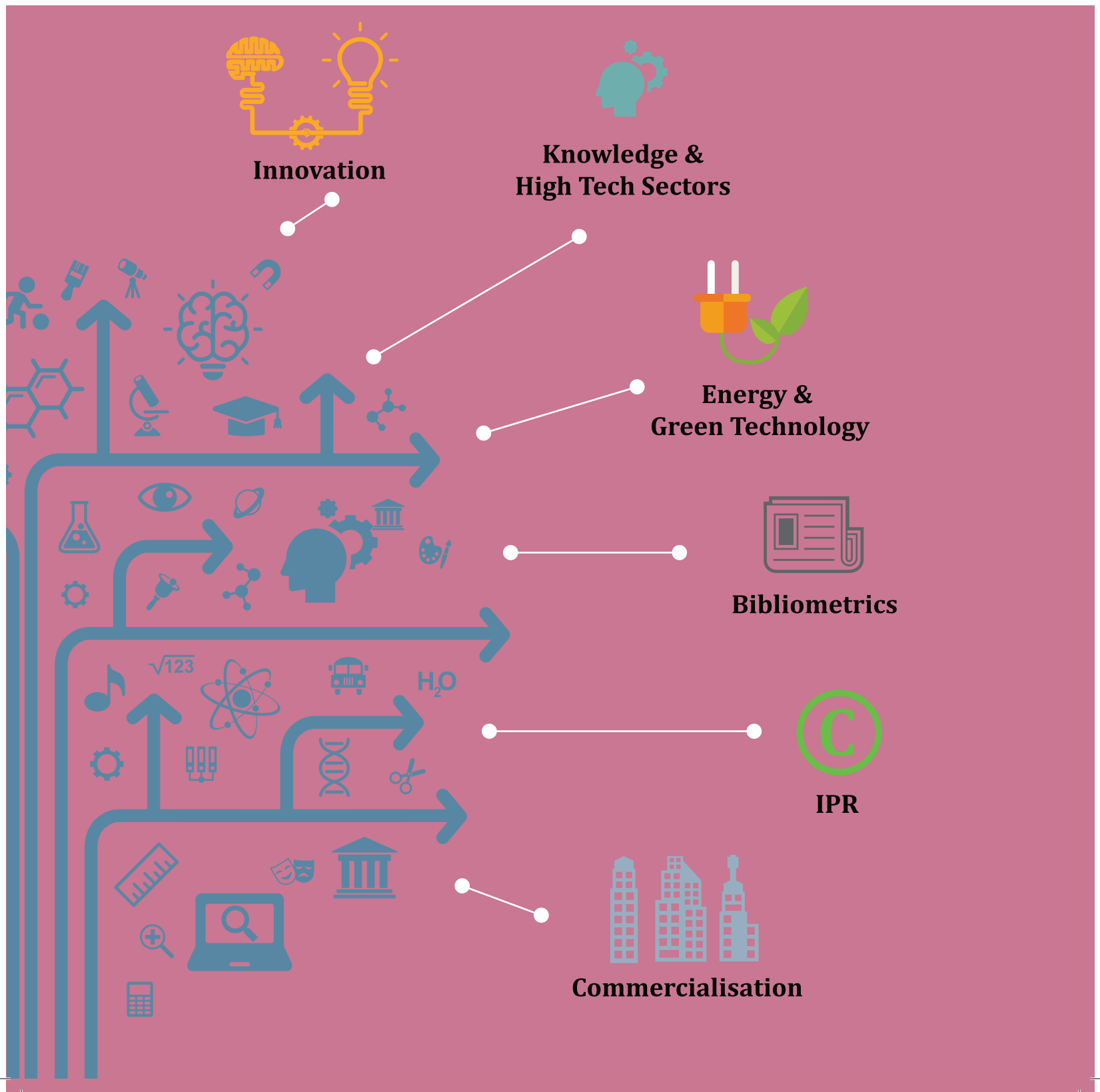
Bibliometrics



IPR



Commercialisation



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CHAPTER 13: CONCLUDING REMARKS AND WAY FORWARD

13.1 Introduction

Malaysian Science, Technology and Innovation Indicators Report 2016 is a volume that records high-quality quantitative data as STI indicators. It represents a reasonable summary of information indicating the scope, quantity and quality of vital STI progress in Malaysia. It is intended to provide understanding of the past and the current National Innovation System of Malaysia, especially to inform the development of future policies and stakeholders who are interested in STI issues. This chapter summarises the main findings and discusses the way forward, providing some general recommendations based on analysis of the trends of the STI indicators, and more detailed investigations are needed to further assess the key takeaways for future policy direction.

13.2 Progress of STI Indicators in Malaysia

The Malaysian Science and Technology Information Centre (MASTIC) under the Ministry of Science, Technology and Innovation (MOSTI) has published the Malaysian Science, Technology and Innovation (STI) Indicators Report biennially since 1994. The Malaysian STI Indicators Report contains a compilation of data from various studies conducted by MASTIC, as well as data obtained from other organisations and agencies pertaining to STI activities in Malaysia. Table 13.1 illustrates the salient findings of the reports. It aims to provide useful insights for relevant stakeholders and individuals to gain a better understanding of Malaysia's STI performance and progress thus far.

Table 13.1 Key Findings: Malaysian STI Indicator Reports 2008, 2010, 2013 and 2016

ASPECTS	2008	2010	2013	2016
Education in S&T	<ul style="list-style-type: none"> • A decrease in the number of registered students in 2006 but picked up in 2007. • An increase in the number of enrolments and graduations at the undergraduate and postgraduate levels in public institutions. • Female students outnumbered male students at the undergraduate and master's levels, but males outnumbered females at the PhD level. 	<ul style="list-style-type: none"> • Additional Mathematics was the subject with the highest registration among science stream students at the SPM level between 2005 – 2009. • A decrease in the number of registered students for science courses at the STPM level. • An increase in the number of enrolments and graduations in S&T at the undergraduate and postgraduate levels in public institutions. • Female students outnumbered male students at the undergraduate level (except in Technical fields) between 2008 – 2009, but males outnumbered females at the PhD level. 	<ul style="list-style-type: none"> • Mathematics had the most registered subjects at the SPM level between 2008 – 2012. • A decrease in the number of registered students for science courses at the STPM level. • Lower enrolments in science courses compared to non-science courses at the undergraduate and postgraduate levels. 	<ul style="list-style-type: none"> • An increase in the number of enrolments for science and mathematics at SPM level over the period 2008 – 2013, with a slight decline in 2014 – 2015. • Females performed much better than males in Science and Mathematics at the SPM level. • A decrease in the number of registered students for science courses in STPM, of between 21% (Physics) – 31% (Mathematic M), over the period 2013 – 2015. • Males tend to score better (A- and above) relative to females in Mathematics (T), ICT, Physics, Chemistry and Biology at the STPM level. • Lower enrolments in science courses compared to non-science courses at the undergraduate and postgraduate levels at public and private universities.

Table 13.1 Key Findings: Malaysian STI Indicator Reports 2008, 2010, 2013 and 2016 (cont'd)

ASPECTS	2008	2010	2013	2016
ICT in Malaysia	<ul style="list-style-type: none"> • PC market growth in terms of numbers and value increased in 2006 – 2007. • Broadband is newly introduced to enable internet access among wireless users. • Malaysia is considered comparable to other well-developed countries in the world in terms of ICT infrastructure and access. 	<ul style="list-style-type: none"> • An increase in penetration rate for cellular telephones and internet access. • Encouraging penetration rate for household broadband. 	<ul style="list-style-type: none"> • ICT access improved significantly, reflecting continuous improvement in ICT technology adoption by the Malaysian population. • An increase in penetration rate for cellular telephones and household broadband. 	<ul style="list-style-type: none"> • Sharp increase in broadband subscriptions between 2009 – 2015. • Overall, in Malaysia the broadband penetration rate per 100 households has increased, from 55.6% in 2010 to 77.3% in 2015. • In 2014, the penetration rate of cellular telephones had reached 148.3 per 100 inhabitants. • Considerable funding for ICT related research, development and commercialisation activities has been provided during the 10th Malaysia Plan. • Significant value added growth in ICT industrial output. • Strength is recorded in some advanced skill categories.

Table 13.1 Key Findings: Malaysian STI Indicator Reports 2008, 2010, 2013 and 2016 (cont'd)

ASPECTS	2008	2010	2013	2016
Public Awareness of S&T	<ul style="list-style-type: none"> Malaysians perceived themselves as weak in terms of knowledge of S&T. Malaysians are beginning to have a more positive attitude towards S&T. Malaysia is far behind many developed countries such as the USA, South Korea and the European Union in their understanding of S&T. 	<ul style="list-style-type: none"> Malaysians perceived themselves as between slightly to moderately interested in S&T issues surveyed. Malaysians perceived themselves as between poor and average in terms of knowledge of S&T. Malaysians have a consistent positive attitude towards S&T. Malaysia lags behind the USA, Europe and South Korea in understanding of S&T. 	<ul style="list-style-type: none"> Malaysians viewed S&T as having a positive impact on individual enjoyment of life, public health, standard of living and working conditions. Malaysians have a consistent positive attitude towards S&T. Malaysia lags behind the USA, Europe and South Korea in understanding of S&T. 	<ul style="list-style-type: none"> Public awareness in Malaysia improved in 2014, with highest interest in the use of new inventions and technologies. Public knowledge of STI has been decreasing since 1998, with some improvement in 2014. Malaysians viewed STI as having a positive impact on public healthcare, working conditions and lifestyle. Malaysians have a consistent positive attitude towards STI. There has been improvement but Malaysia still lags behind the USA, the EU and South Korea in public knowledge of STI.
R&D	<ul style="list-style-type: none"> Increased in 1996 – 2005. R&D expenditure continued to increase in 2006. 	<ul style="list-style-type: none"> National GERD dropped drastically in 2006 – 2008. The GERD/GDP ratio dropped in 2006 – 2008. 	<ul style="list-style-type: none"> National GERD increased in 2006 – 2011. The GERD/GDP ratio increased in 2004 – 2011. Improved over the years but is still considered low compared to developed countries such as Singapore, South Korea and Taiwan. 	<ul style="list-style-type: none"> National GERD/GDP stood at 1.26% and Malaysia ranked 31st in WCY 2016. GERD and GERD/GDP has had continuous growth since 2006. Government R&D funding recorded a significant increase, from 29.68% to 44.96% in 2012 – 2014. BERD has been in a decreasing trend since 2012.

Table 13.1 Key Findings: Malaysian STI Indicator Reports 2008, 2010, 2013 and 2016 (cont'd)

ASPECTS	2008	2010	2013	2016
Human Resources in S&T	<ul style="list-style-type: none"> A decrease in headcount and FTE in R&D in 2006. R&D research dominated by male researchers with PhD degrees and working within the HLIs environments. A decrease in participation of women in R&D in 2006, but increase in proportion of female personnel. 	<ul style="list-style-type: none"> A decrease in headcount of R&D personnel and FTE for the private sector. An increase in FTE for the HLIs. An increase in participation of women in R&D. 	<ul style="list-style-type: none"> An increase in headcount of R&D personnel, with the highest headcount in 2011. A marked increase in researchers with Master's and PhD degrees. A steady increase in participation of women in R&D. 	<ul style="list-style-type: none"> R&D personnel recorded 114,539 persons, and the ratio of researchers to 10,000 workforce was 60.66 in 2014. Efforts to increase the targeted 70 researchers per 10,000 workforce by 2020 have to be intensified. A significant increase in researchers with Master's degrees. Slight decrease in the proportion of female researchers in 2012 – 2014.
Public Sector Support for R&D	<ul style="list-style-type: none"> Various grants are available and disbursed, mostly for the areas of biotechnology, electrical and electronics, and ICT. 	<ul style="list-style-type: none"> Government has provided numerous grants and incentives for R&D in S&T. Positive response from public and private institutions reflects their awareness of the existence of these programmes, and their keen interest in being involved. 	<ul style="list-style-type: none"> Government continues to provide various grants and incentives to promote R&D activities. Positive response from public and private institutions continues to be observed. High degree of importance is placed on not just R&D, but also on commercialisation of R&D output – especially in biotechnology. 	<ul style="list-style-type: none"> Government continues its commitment to provide funds to support R&D activities ranging from ideation to commercialisation. ScienceFund, TechnoFund, FRGS, CRDF and BCF are the main funds. Establishment of funds related to creative and content industries.
Innovation	<ul style="list-style-type: none"> Innovations focused on biotechnology products, computing and machinery in 2002 – 2004. Huge allocation of government grants is disbursed to industries for innovations in biotechnology, motor vehicles and machinery, and ICT. 	<ul style="list-style-type: none"> Malaysia ranked 24th in innovation competitiveness and 26th in global competitiveness in the GCI 2010 – 2011. Malaysia ranked 12th in innovative capacity and 10th in world competitiveness in WCY 2010. 	<ul style="list-style-type: none"> Malaysia ranked 23rd in innovation and 25th in competitiveness out of 144 countries in the GCI 2011 – 2012. Malaysia ranked 13th in innovative capacity of firms in generating new products and processes in WCY 2013, behind developed countries such as Israel (1st), the USA (2nd) and Switzerland (3rd). 	<ul style="list-style-type: none"> Innovative companies in both manufacturing and services sectors are mostly small, private limited companies. Malaysia ranked 18th in competitiveness out of 140 countries in GCI 2015 – 2016. Malaysia ranked 35th out of 128 countries and 59th in innovation efficiency ratio in GII 2016.

Table 13.1 Key Findings: Malaysian STI Indicator Reports 2008, 2010, 2013 and 2016 (cont'd)

ASPECTS	2008	2010	2013	2016
Trade in Technology/ Knowledge and Technology Intensive Industry	<ul style="list-style-type: none"> High-technology products dominates the total manufactured goods for exports. Positive trade balance of high-technology manufactured goods, but negative balance of medium high-technology goods in 2005 – 2006. Receipts in royalty accounts has not shown significant improvement in 2001 – 2008. The services observe overall record deficits in 2001 – 2008 despite showing improvements in the receipts. 	<ul style="list-style-type: none"> Trade surplus in high-technology industry products declined in 2009, and trade deficit in medium high-technology products reduced drastically in 2009. Malaysia is ranked 8th in the list of top exporters of high-technology products in the world in 2008. 	<ul style="list-style-type: none"> High-technology manufacturing sector records declining production levels and total exports in 2012. Knowledge-intensive services sector records steady increase in production. Globally, Malaysia's share in knowledge- and technology-intensive industries is only 0.2% of the world. 	<ul style="list-style-type: none"> In high-technology industries, testing, measuring and control instruments, pharmaceutical, and aircraft and spacecraft sectors record impressive export growth between 2010 – 2014. Health and social services, education services and business services are among the top knowledge-intensive services registering significant value added growth between 2010 – 2014. Malaysia's average value added growth of high-technology products and average growth of knowledge-intensive industry is lacking behind other ASEAN nations like Singapore, Indonesia and the Philippines.
Biotechnology/ Green technology	<ul style="list-style-type: none"> Healthcare industry dominates industrial distribution, followed by agricultural, industrial and bioinformatics. Highest number of students graduated in Food Science followed by Pharmacy / Pharmacology. 505 jobs were created in biotechnology in 2007. 	<ul style="list-style-type: none"> Total number of participants in and revenue from biotechnology have increased. Biotechnology firms focused on healthcare, industrial and agricultural biotechnology. RIs and HLIs participated in agricultural, healthcare and industrial sectors in biotechnology. 	<ul style="list-style-type: none"> Positive growth of biotechnology firms, R&D and revenue in terms of numbers. Core sector in biotechnology is the agricultural sector, with fast growing industrial and healthcare sectors. 	<ul style="list-style-type: none"> Gradual progress in green technology diffusion due to various incentives and programmes. Source of energy mix is still predominantly coal and natural gas but carbon footprint in Malaysia has reduced over the years 2000 – 2011. Challenges remain in diffusing the renewable technologies given the lower cost of fossil fuels, high cost of renewable technologies, high investment requirements and limited technological know-how.

Table 13.1 Key Findings: Malaysian STI Indicator Reports 2008, 2010, 2013 and 2016 (cont'd)

ASPECTS	2008	2010	2013	2016
Publications and Citations	<ul style="list-style-type: none"> Increased publications by fourfold within 2001 – 2008. Malaysian authors received 2.4 citations on average per publication. 	<ul style="list-style-type: none"> Rapid rate of increase in number of publications and citations within 2000 – 2009. Establishment of Apex and Research Universities helped to increase the number of publications and citations for Malaysia. 	<ul style="list-style-type: none"> Positive growth in number of publications and citations. Decline in annual growth rate for publications and citations. 	<ul style="list-style-type: none"> Significant increase in number of publications and citations. “Materials Science” with publications reporting multidisciplinary research findings emerged as the top field in sciences with highest article counts. In terms of citation counts, Malaysia performed at a comparatively lower level than many other countries.
IPRs and Commercialisation / Royalties and Licensing Fees	<ul style="list-style-type: none"> An increase in the number of patent applications by Malaysians. More patents are granted in 2006 – 2008 compared to 2001 – 2005. An increase in the number of trademark applications and number of trademarks granted. A decrease in the number of industrial design applications and number of registered industrial designs. Globally, Malaysian innovative works are insignificant due to small number of patents applied to and granted by the USPTO. 	<ul style="list-style-type: none"> A significant increase in the number of patents filed and granted, with notable increase of Malaysian applicants. A notable increase in local patent applications by universities and research institutes. Malaysia has consistently experienced a deficit in the balance of payments for royalties and licensing fees in 2001 – 2009. 	<ul style="list-style-type: none"> Promising growth in application of PCT patents by HLIs and PRIs. Malaysia is one of the top five middle-income countries in the application of PCT patents, behind Turkey, India and China. Strong growth of varying degrees for the domestic filing of patents, trademarks and industrial designs. Malaysia continues to record a deficit since 2005 in terms of balance of trade in intellectual property. 	<ul style="list-style-type: none"> Malaysia's patent and utility innovation applications trend in MyIPO increased during 2011 – 2014. Information and communication technology emerged as the dominant field in Malaysia's patent application landscape. Trademark applications more than double in 2015 compared to 2001. During 9th Malaysia Plan, 8% of publicly funded R&D projects were commercialised. The trade of royalties and licencing fees is in deficit. Higher commercialisation is seen in fields such as medical and health, ICT and agriculture.

Source : Compilation from STI Indicators Report, 2008, 2010 and 2013

13.3 Potential Areas for Progress, Areas Needing Improvement and Recommendations

Earlier sections of this report have analysed and supplied the progress of STI, comparing the past STI development and current status of STI in Malaysia. The analysis affirms that Malaysia has achieved significant progress in key areas that are essential for national STI advancement. This final section recaps further the potential areas for progress – as well as the areas needing progress – and reiterates a set of broad recommendations for decision-makers and practitioners in Malaysia’s STI ecosystem.

a) Human Capital Development: Secondary and Tertiary Education in Science and Technology

Potential Areas for Progress – Generally, the performance of the students in science and mathematics at the SPM level has improved over the period 2008 – 2013, in the sense of an increase in percentages of students scoring A and above for mathematics and science. These trends are encouraging, and suggest that the move at the ministry level – towards encouraging a deeper understanding in the subject matter through teaching and learning – has recorded some success. At the STPM level, the performance in terms of scores for science and mathematics has generally been high and remained relatively consistent throughout the years. The number of failures for both science and mathematics illustrates a decreasing trend, which suggests an improvement in the understanding of science and technology. Although Malaysia is yet to achieve the 60:40 (science to non-science) ratio, there is an increasing trend in enrolment for programmes such as Engineering, Health and Computing – which jointly contribute more than 70% of all STEM enrolment in both undergraduate and master’s programmes over the period 2011 – 2015. For these, there is a need to identify mechanisms to leverage and utilise the pool of talent, especially for the private sector. The ability to successfully match supply with demand for education and skills will ensure the relevance and alignment of the programmes to economic development goals.

Areas Needing Improvement – At the international level, Malaysia’s performance in the OECD’s PISA and TIMSS surveys has always been significantly below OECD and TIMSS global score averages. PISA focuses on evaluating the problem solving skills and knowledge of 15-year-old students in the keys areas (reading literacy, mathematics and science literacy), and TIMSS focuses on formal mathematical knowledge (content) – hence these results should serve as an indicator that Malaysia must improve on the quality of learning and teaching in science and mathematics education. The disparity between the findings from our internal assessment and that of the international assessment may be largely attributable to the weaknesses in the teaching delivery and the content of the curricula. In 2011, findings from research by the Higher Education Leadership Academy (AKEPT) conducted on 41 schools indicated that 50% of the lessons delivered did not sufficiently engage students, and instead relied on a more passive lecture format of content delivery – the focus was more to prepare students for summative assessment purposes, instead of cultivating higher-order thinking skills. The Ministry of Education, through the launch of the Malaysia Education Blueprint (MEB) 2013 – 2025, has addressed the need for a transformation within the education system. The changes laid out in MEB 2013 – 2025 itself are very ambitious to ensure that the Malaysian education system is in the top third of countries in terms of performance in international assessments as measured by TIMSS and PISA. However,

the ultimate challenge for this is to ensure a sustainable capacity and capability to deliver reforms at the school level, with sustained and lasting impact on students. At public universities, the ratio of science to non-science enrolment stands at around 45:55 for undergraduate programmes and 50:50 at the doctoral level, short of the government's target of 60:40.

Recommendations – To reduce the gaps and to facilitate improvement within the education system, and relevant to 21st century education as well as to be at par with international standards, the following measures – which are commonly employed in many countries especially among the top performers in Asia – must be addressed and adhere to:

- Setting clear goals with high and rigorous academic standards: This is an important component to ensure that students have a strong early foundation in the core subjects of mathematics, science and literacy.
- Development of curriculum, instruction and assessment to match the standards: Efforts to improve student achievement must include strengthening the rigor of curriculum standards, and increasing advanced course-taking to ensure greater focus on high-level, complex skills.
- Recruitment of high-quality teachers and principals: It is necessary to have a comprehensive and intensive human resource system to obtain high-quality teachers and school leaders, accompanied by coherent training and serious and continuous support. Every school must have a fair share of the best STEM teachers.
- Vision and persistent leadership: Studies have shown that changing any system takes five to ten years. Thus, the need for leaders with a bold long term vision of the role of education in society and the economy is essential for creating educational excellence.
- Ensuring the alignment of the education system to economic development goals.
- Coherence of the education system: This aims at reducing the enormous gap between policies and their implementation at the school level – from the ministry right to the teachers – and will result in greater alignment in the standard across schools.

b) Public Awareness of STI

Potential Areas for Progress – Malaysian public awareness of STI improved in certain areas in 2014, with most of the respondents in the national Public Awareness of STI 2014 survey indicating interest particularly in the use of new inventions and technologies. In addition, the national awareness surveys reveal that respondents with higher level of education tend to be more interested in STI issues, pointing towards the potential of leveraging formal education on STI to raise the level of STI awareness. Malaysian respondents generally have a positive attitude towards scientific research and STI, with most of them perceiving greater benefits than harm from scientific research. They also mostly viewed STI as having positive effects on areas such as public healthcare and lifestyle. Television is the key source of information on STI issues as well as the most reliable source as perceived by Malaysians. In recent years, the Internet is becoming increasingly popular as the chosen source of information on STI issues. These two key media will be essential in the efforts to disseminate information,

to increase public knowledge and to encourage more interest on STI.

Areas Needing Improvement – Although there was a slight improvement from 2008 to 2014, public knowledge of STI among Malaysians generally has also been decreasing since 1998, at some distance behind their counterparts in developed countries such as the USA, the EU, South Korea and Japan. Malaysian public knowledge on STI is lacking, particularly concerning STI topics on specialised topics or issues. There has also been a decline in interest among Malaysians over the years, particularly on environmental pollution issues. Notably, there is a lack of public awareness and participation in STI related programmes conducted by the government. Effective outreach programmes are necessary to promote these programmes to the general public.

With the rise in popularity of the Internet, Malaysians can access a plethora of available information which may be misleading or inaccurate at times. Although the Internet is popular, only a small percentage of respondents find it to be a reliable source of information. It may be imperative for the public to have an authoritative reference point when in doubt regarding STI matters.

Recommendations – The recommendations as the way forward to address the shortcomings are:

- Intensify efforts to raise the level of STI awareness through formal STEM education at all education levels, particularly in primary schools. Interest in STI among school children has to be stimulated since young, to build a lasting scientific culture in the Malaysian public.
- Dissemination of information on STI – such as on environmental pollution issues – should be performed through television and the Internet to reach a wider audience. The rise in popularity of the Internet as a key source of STI information should be harnessed as a cost effective and time efficient tool to disseminate relevant STI information to the general public. Newspapers and radio should also be used to reach out to different segments of the community.
- STI related programmes may be made available as web-enabled programmes on the Internet to be more interactive and appealing to Malaysians, especially the younger generation. The use of the Internet also eliminates the need to travel to specific locations to experience or participate in the organised STI programmes, and hence widens the reach of these programmes (instead of being confined to just the local community where the events are organised).
- Non-formal approaches such as scientific fairs and competitions to promote STI awareness that require the community to relate science to everyday life may be employed. This might help the Malaysian community to appreciate that science improves their economic, social and cultural well-being.
- Institutions that command the public confidence on STI matters should be fostered to combat misinformation and pitfalls that come with easy access to information, especially through the Internet. Institutions such as the National Science Centre and Academy of Sciences Malaysia may be positioned as the institutions of authority on STI matters – a definitive reference point for the public for all matters on STI.
- Outreach activities should be intensified to promote STI programmes due to the current lack of awareness and participation in government STI programmes.

Empowering other stakeholders including NGOs, private companies and public sectors can be considered to ensure effective delivery of the outreach programmes, as well as to reach wider and more comprehensive segments of audiences.

c) Information and Communication Technology

Potential Areas for Progress – The consumption and demand of ICT indicates the trend of usage of ICT services and related products in Malaysia. It is noteworthy that the penetration rate for broadband has increased sharply, while cellular phones has reached a breakpoint. Malaysia witnessed tremendous value added growth in ICT industrial output, contributing RM70.89 billion in value added activities in 2015. Malaysia exhibits strength in some advanced categories such as “Software & Application Development” and “OS & Server Technologies”. The relevant government agencies can intensify their joint efforts with stakeholders in the ICT industries and leverage these strengths to create new industries. Such efforts can lead to creation of new market opportunities, employment and expansion of Malaysia’s ICT businesses in the global production value chain.

Areas Needing Improvement – Many advanced economies such as Germany and South Korea emerged as the leaders in terms of fixed broadband penetration rate. They performed way ahead of developing countries. While Malaysia performs at a level above many countries in Southeast Asia, it lags behind many advanced countries in the world.

Recommendations – The demand for broadband services is highly likely to increase in the future. Efforts should be targeted as a way forward in the following areas:

- Setting higher broadband penetration rate targets and benchmarking the more advanced nations, given that penetration rate is crucial for overall economic development – especially in facilitating business growth among Small Medium Industries.
- Identifying policy lessons and development paths to further accelerate the contributions of the ICT industry. Malaysia can chart a roadmap for its ICT industries that favour its own strengths. The growing broadband market can be used as a test bed for new technological products and services that emerge from Malaysian ICT industries.
- Coordinating funding sources (both public and private) to fund R&D and entrepreneurship, in order for skilled and talented individuals to commercialise ICT related products and services. The funding can also be used to provide solutions to the common technical constraints that industry faces. Models like Collaborative Research in Engineering, Science and Technology (CREST) can be looked at.

d) R&D Investment and Research Workforce

Potential Areas for Progress – There has been significant growth in GERD and GERD per GDP since 2006. In 2014, Malaysia’s GERD per GDP stood at 1.26%, which was the best achievement of the country. This upward trend was due to the strong commitment of the Government in intensifying the national R&D intensity. Similar to R&D investment, human capital development in STI is also on a positive trend; in

2014 the total R&D personnel for Malaysia was 114,539 persons, while the ratio of researchers to 10,000 workforce was 60.66 – both new milestones for the nation. Such a talent pool is the backbone of Malaysia's quest for STI development. In regard to GERD distribution by type of research, efforts and strategies from the Government in promoting applied research with higher commercialisation potential has resulted in the dominance of Applied Research in all sectors (i.e. HLIs, GRIs and BEs). This can also be seen in the dominance of Applied Research across all types of research activities (such as basic and experimental development research) that increased from 50.49% to 75.53% during the period of 2012 – 2014. In order to optimise the benefits of this applied research, there should be a mechanism to reap the fruits of the research that eventually increases the level of R&D commercialisation of the country. Internationally, Malaysia's performance in R&D investment and human capital development in STI were commendable in 2014 in the ASEAN region. The IMD WCY 2016 indicates that within ASEAN, Malaysia was behind only Singapore in terms of GERD, GERD per GDP, BERD per GDP, and FTE per 1,000 people.

Areas Needing Improvement – However given the trend from 2000, the National Survey of R&D in Malaysia 2015 forecasts that Malaysia could only achieve 1.83% of GERD per GDP in 2020, as opposed to the targeted 2.0% designated by the National Policy for Science, Technology and Innovation (NPSTI) 2013 – 2020. Also, R&D in Malaysia is mainly public driven, in which Government R&D funding recorded a significant increase from 29.68% to 44.96% during 2012 – 2014. The issue more concerning to policymakers is that BERD has been in a decreasing trend since 2012. The latest R&D survey in 2014 indicated that nearly 44.96% of R&D funding was contributed by the Government, while BEs only funded 25.23% of the R&D activities in Malaysia. As a whole, this trend does not match the country's agenda in developing SMEs as a main innovation driver of the NKEAs. Although there is the possibility of under-reporting of the actual number of BERD³¹, serious measures are needed to foster BEs contribution to GERD. It is also an important to establish a systematic structure to capture the accurate number of GERD which is apparently missing from our current National Innovation System.

In the case of human capital development, efforts to reach the targeted 70 researchers per 10,000 workforce by 2020 have to be intensified. There is also an issue of the lack of proper documentation or registrar for keeping track of researcher headcount – such data is crucial for policymakers in charting the future national STI development plans and strategies. Additionally, the gap between Malaysia and developed nations in OECD and NIEs still remains wide, in both R&D investments and human capital development in STI.

Recommendations – The recommendations to be considered for fostering R&D investments and research workforce include:

- Establishing an institutional STI framework with legal structure to require mandatory reporting of R&D by all sectors.
- Enhancing collaboration and data sharing with other ministries and agencies in R&D data collection, as well as streamlining the data parameters in accordance

³¹ According to National R&D Survey 2015, MOSTI does not have legal authority to require mandatory reporting of R&D by BEs, HLIs and GRIs. The Statistics Act 1965 (Revised 1989) used by the Department of Statistics Malaysia was deemed not to cover R&D.

with the Frascati Manual 2015.

- Monitoring the effectiveness of incentives relating to BERD by analysing the take-up and success of the R&D tax credits and R&D funds.
- Maintaining and gradually increasing basic research while sustaining a high share of applied research.
- Intensifying the execution of Human Capital Roadmap for Science and Technology 2012 – 2020 (HCRST) to foster human capital development in STI.
- Strengthening efforts in creating a database for keeping track of researchers by headcount and qualification.

e) Public Sector R&D Investment – Major Grants and Programmes

Potential Areas for Progress – The commitment of the Government in enhancing the overall STI performance of the nation is clearly reflected in the full range of public R&D investments made available by the various ministries and agencies. These public R&D investments are designed and implemented in the forms of grants, incentives and programmes that encompass the four stages of STI development – i.e. pre-R&D, R&D, development and commercialisation – in the form of both up-front incentives and tax incentives of R&D expenditure. All clusters – namely S&T Core, Industry, S2S, Biotechnology, ICT and Nanotechnology – have benefited from the R&D investments during the period of 2011 – 2015. Besides several main grants such as ScienceFund, TechnoFund, FRGS, CRDF, BCF, etc., we also witnessed the establishment of several funds related to R&D in ICT, creative and content industries – such as PCF, MAC3 and BCi2.

Areas Needing Improvement – Despite a wide spectrum of R&D funding schemes and mechanisms that have been made available by the Malaysian government through its various ministries and agencies, one of the main findings from the National Survey of R&D 2015 indicated that our research communities – HLIs, GRIs and GRIs – still cited insufficient government funding as one of the key factors hampering their R&D progress. Besides, the Science Outlook 2015 has raised concerns over the short-term approach to R&D grants management adopted in the 10th Malaysia Plan³². The grant administration and monitoring systems that are based on a five-year rolling plan have resulted in uncertainty among the researchers and institutions and discouraged long term, high impact R&D projects. This is evidenced in the significant decrease in the numbers and value of projects approved across all the R&D grants in the last two years of the rolling plan. Moreover, government R&D funding and support were found to be inconsistent especially during the current economic downturn. There is a need for continuous public R&D funding, and R&D should be perceived as a long term investment.

Recommendations – The key recommendations to enhance the public investment

³² According to Science Outlook 2015, “Typically in Malaysia, the progress of R&D is only monitored across a five-year cycle. Long term research project continuity may not be a priority. In the 10MP (2011 – 2015), R&D activities are treated as a rolling plan, creating uncertainty among GRIs. Research activity planning in the early stages is hampered given the short term treatment of R&D activities, and may not necessarily reach the commercialisation stage (ASM, p.64).”

system in R&D should be considered as follows:

- Enhancing the breadth and depth of knowledge regarding the existing R&D grants and programmes among the R&D communities, as well as strengthening their skills to access them.
- Intensifying training to foster the skills needed to transform research ideas – as well as routine work - into research among the researchers and industry practitioners.
- Establishing long term stability in funding in the current research system, to ensure the success of national STI agendas which are only attained over a longer time horizon.
- Initiating a comprehensive study on the effectiveness of the short term approach, such as the rolling plan approach in R&D grant administration.
- Streamlining the management, administration and coordination of the funds that involve multiple agencies and stakeholders.

f) Innovation in Manufacturing and Services Sectors

Potential Areas for Progress – More than two thirds of the companies in both manufacturing and services sectors are found to be innovative. These companies are mostly small private limited companies, recording high annual sales against low expenditures for innovation activities. The services sector is found to be more innovative than the manufacturing sector. The main objectives of innovation activities by these companies are to improve product quality and to fulfil regulations and standards. These companies have observed the highest impact of product and process innovation, as well as marketing and organisational innovation on the quality of goods or services.

Areas Needing Improvement – High cost of innovation is the most important factor that hampers innovation activities in the manufacturing and services sector in Malaysia. Innovation activities in companies are mostly funded using own funds. Nevertheless, there is a lack of funds within the organisation, as well as a lack of finance from sources outside the organisation for innovation activities. In addition, only about one third or fewer of the companies in both sectors indicated that they received some form of government support. However, this may be attributable to a lack of awareness of available government support for these sectors. Hence, there is a need to find ways to raise the level of awareness of available government support and innovation funding for these sectors. Lack of qualified personnel and lack of information on technology point towards the need for competent human capital to drive innovation activities in the manufacturing and services sectors. An innovative culture instilled through education is needed to produce a workforce that is competent, knowledgeable and innovative for the sectors.

Recommendations – In order to reduce the gaps and to facilitate innovation activities in the private sector, the following may be considered:

- Creating a matching funding system for industries especially SMEs, universities and PRIs to manage the high cost of innovation, and to sustain an innovative culture and practices for these organisations.

- Revising and enhancing the current mechanisms that support innovation activities, such as tax incentives and R&D grant systems for the companies in Malaysia.
- Leveraging innovation intermediaries as well as encouraging all stakeholders to play an active role in providing the ideal environment for innovation – such as obtaining more investments in innovation activities from business angel investors and philanthropists to tackle the high cost of innovation, and liberalising relevant regulations by the government to promote innovation.
- Providing effective educational and promotional programmes to raise the level of awareness of available government supports, incentives and innovation funding to the private sector.
- Encouraging and enhancing partnership and collaboration between GRIs, universities and industries to bridge the gap between the knowledge from research institutions and industry. The research institutions and industry should be brought together in solving industry problems, advancing transfer of knowledge and training skilled personnel for STI to speed up innovation.
- Strengthening the exchange of R&D results between GRIs and universities with industry. More transparency should be imposed on both parties to share information on innovation activities.
- Cultivating competent, knowledgeable and innovative culture within the companies. This may be done by providing up-skilling programmes to employees as well as by disseminating positive information on innovation, for example by highlighting the fact that innovative companies generate high annual sales but low expenditures.
- Encouraging the companies in Malaysia to attract and employ more personnel with Master's or PhD degrees by offering competitive salaries and benefits.
- Instilling innovative culture among the younger generation through education at all levels as a long term measure, such as by strengthening the entrepreneurship based curriculum in schools or organising innovation competitions for more exposure on innovation activities to stimulate the young.

g) Knowledge and Technology Intensive Industries

Potential Areas for Progress – The annual average growth of Knowledge Intensive sector's value added in Malaysia from 2000 to 2014 is 14.92%. Financial services and business services contributed the most to the total value added output. In terms of annual average value added growth, health and social services, education services and business services registered significant growth of 37.39%, 32.21% and 23.75% respectively. In high-technology industries, the semiconductor industry contributed the most in terms of value added output. The testing, measuring, and control instruments, pharmaceutical, and aircraft and spacecraft sectors recorded impressive annual average export growth of 30.52%, 24.68% and 15.17% respectively during 2010 – 2014. Malaysia registered a trade surplus in HT industries from 2000 to 2014. In fact, Malaysia's trade balance performance excels in HT industries compared to developed nations such as the United States. Malaysia has a comparative advantage in HT industries compared to commercial KI services.

Areas Needing Improvement – Malaysia's KTI industry contribution to GDP remained without much increase over the years. Malaysia's value added of HT industry in 2014 is relatively lower compared to neighbouring countries such as Singapore. Computer and office machinery recorded declining value added activities over the years. Comparatively, in 2014 Malaysia's knowledge intensive (KI) industry value added output was lacking behind compared to other ASEAN nations like Indonesia, the Philippines, Thailand and Singapore. Ultimately, Malaysia is losing its long term competitiveness to other ASEAN countries, especially in the KI services industry. It is noteworthy that from 2004 to 2013, Malaysia is documented to have had a consistent trade deficit in commercial knowledge intensive services compared to other ASEAN nations like Singapore and the Philippines.

Recommendations – Given the need to improve the contribution of the KI and HT industries in Malaysia, the way forward should consider the following:

- Reinforce enablers of the HT industry's growth – such as access to finance, technology transfer, logistics, infrastructure support and skilled workforce – to further promote value added activities.
- Attract adequate investment in KI industries and foster linkages among players to enhance the value added activities. Sharing of know-how and technology is crucial to promote value added output.
- HT and KI are industries that are highly R&D intensive, and mechanisms to foster R&D and innovation activities should be identified and intensified.
- An effective institutional coordination is needed to monitor and ensure the implementation of HT and KI intensive industrial plans. Agencies such as the Malaysian Industry-Government Group for High Technology can play a critical role.

h) Energy and Green Technology

Potential Areas for Progress – Malaysia was successful in reducing its carbon emission intensity by 33% in 2015 relative to its 2005 level. Further commitment was made to reduce the GHG emissions intensity by 45% by 2030. Installation capacity of renewable energy shows a positive trend. The planned net metering and other initiatives such as green vehicles, green buildings and others are expected to improve the STI agenda in RE of Malaysia, especially with regard to STI in green technology and research and development. Various initiatives and programmes have contributed to the emissions reduction.

Areas Needing Improvement – The source of energy mix is still predominantly fossil fuels, namely coal and natural gas. Challenges remain in diffusing the renewable technologies given the lower cost of fossil fuels, high cost of renewable technologies, high investment requirements, limited financial access and limited technological know-how. Despite the efforts, progress is still limited and more concentrated targets and plans are needed to move forward into a green economy.

Recommendations – Improvements in the future should target the following:

- Promoting and devising mechanisms for the demand side management of energy, namely energy efficiency – especially in the residential and industrial sectors.
- Intensifying technological collaboration including R&D with regards to green technologies, as well as promoting trade in green technologies.
- Improving the institutional and policy coordination so that targets can be achieved among the various agencies.
- Promoting investment in green technology including foreign direct investment, and improving financial access for green technologies.
- Improving trade facilitation mechanisms to further enhance green technology adoption and diffusion of renewable energy technologies.

i) **Bibliometrics: Publication and Citations**

Potential Areas for Progress – Malaysia’s performance in scientific publication is commendable. The publication performance has increased, from 17,283 articles in the period of 9th Malaysia Plan to 35,720 in 10th Malaysia Plan. Public and private universities had both stepped up to boost the publication counts. UM, USM, UPM, UKM and UTM are among the top institutions in publications. It is noteworthy that there are productive PRIs that contributed to the pool of scientific publications. The Institute for Medical Research and the Malaysian Palm Oil Board are among the performing PRIs. Science and Social Science publication average growth were 17.7% and 25.3% respectively since 2007. Malaysia has exhibited strength in many fields such as Materials Science, Crystallography, and Electrical and Electronics Engineering. Malaysia can leverage the accumulated scientific knowledge by devoting some funds for those who wish to perform applied research or commercialisation activities in these fields of research. There are a large number of joint publications with scholars, both local and abroad. Such networks can be intensified to strengthen fields that were not listed as top fields of research. It is important to identify the fields of research where Malaysia has comparative advantages, and leverage those fields to benefit industries or potential industries that can emerge in the near future.

Areas Needing Improvement – While performance in publication is noteworthy, citation counts have to be improved. Singapore and Thailand are the two leading ASEAN countries in terms of citation counts, while Malaysia performed at a comparatively lower level. For citations per paper of selected fields of research, there are many fields where Malaysia lagged significantly behind the top country.

Recommendations – Given the relatively low citations per article and Malaysia’s lower performance in certain fields, the following should be considered:

- Improving the research quality through international collaboration. Malaysia can leverage existing publication networks with some advanced countries in research to improve its research quality, and identify new emerging fields that can benefit socio-economic development.
- Improving the research visibility through various mechanisms – e.g. social media, organisational websites, international networks and others.

j) Intellectual Property Rights

Potential Areas for Progress – Malaysia has demonstrated technological ability and made progress in patenting and other intellectual property rights. MyIPO is instrumental in promoting invention disclosures. There is a consistent increase in patenting activities. “Human Necessities”, “Performing Operations; Transporting” and “Chemistry; Metallurgy” emerged as the top fields of technology. There are local organisations such as MIMOS and UTM actively patenting their inventions. The trends for trademark applications and registrations imply consistent efforts of producers to market innovation in Malaysia. A similar pattern of growth can be noted for the case of industrial design applications and registrations. Malaysia’s efforts to perform in PCT patenting are commendable – it has been recognised as one of the top economies in PCT patent applications. Malaysia can indeed appropriate the patenting efforts through various commercialisation efforts, such as licensing or start-ups based on patents.

Areas Needing Improvement – Foreign patent and utility innovation applications have indeed dominated the patenting landscape of Malaysia. The share of Malaysia’s patent and utility innovation applications only ranges from approximately 10% to 20% since 2010. In addition, establishing functional mechanisms to commercialise the local inventions is essential. It needs to leverage the potential Malaysia has attained for patenting activities.

Recommendations – The following should be considered to further strengthen the IPR regime:

- Increasing the local participation in patenting activities, especially local industry participation given that patenting activities among foreign entities is relatively high. It is also important to ensure existing momentum in patenting activities of certain local organisations would ultimately spill over technological knowledge to other local entities. Local organisations and companies should be encouraged to file for IPRs via tax incentives and financial support.
- Identifying translation mechanisms is crucial to commercialise the inventions in certain markets. Malaysia may need to find local partners to identify demand and make Malaysia’s inventions applicable for certain market contexts or needs.
- Encouraging joint patenting activities between the local organisations and entities from abroad is crucial to realise the desired commercialisation of Malaysia’s inventions abroad.

k) Commercialisation and Return on R&D Investment

Potential Areas for Progress – Malaysia has gradually progressed in commercialisation activities. In the 9th Malaysia Plan, 8% of the publicly funded R&D projects were commercialised. Relatively, commercialisation success is higher in fields such as medical and health, ICT, and agriculture. Similarly, a few organisations have showed significant success in commercialisation activities due to market orientation activities that the organisations have undertaken, including having close linkages with industries. Some of the best practices of these organisations should be looked at to understand the potential drivers of commercialisation success – these can provide lessons to other organisations. Surveys show that the private sector is more successful

in commercialisation activities than the public sector. The potential of the private sector's commercialisation efforts needs to be enhanced further.

Areas Needing Improvement – Malaysia also experienced large trade deficits in royalties and licensing fees. Overall, universities and public research institutions are still weak in commercialisation activities despite recording increasing patenting activities.

Recommendations – The key general recommendations are:

- Intensify the private sector's commercialisation activities through tax incentives and other forms of support system.
- Identify promotional mechanisms to promote local talent (individuals, companies, universities and other organisations) to improve the services rendered by Malaysians to others globally.
- Monitor the commercialisation activities and identify potential technologies to further promote the market for those technologies.
- Create a holistic database for the promotional activities of those inventions in universities and PRIs.
- Improve industry-academia collaboration activities to further make academia research take-up possible.
- Identify the key success factors of the organisations that are successful in commercialisation to provide lessons to others.

13.4 Summary

Malaysia has attained progress in many aspects of the STI ecosystem. Nevertheless, there is more room for improvements and many challenges remain. New targets and strategies are needed to mitigate the shortcomings. This study has identified the potential areas in which Malaysia has already built strengths, and conversely areas needing improvement. Broad recommendations are given as key takeaways for future consideration. These recommendations are based on the analysis of the trends of indicators – which is general in nature – and more detailed investigations and engagement with various stakeholders are needed to further assess the recommendations for future policy direction.

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ABBREVIATION

AKEPT	Higher Education Leadership Academy
ANGKASA	National Space Agency
ARIPO	African Regional Intellectual Property Organisation
ARSM	Malaysian Remote Sensing Agency
ASEAN	Association of Southeast Asian Nations
ATSB®	Astronautic Technology (M) Sdn. Bhd
BCF	Biotechnology Commercialisation Fund
BCG	Biotechnology Commercialisation Grant
BCi2	Bumiputera Content Industry Initiative
BDA	Big Data Analytics
BERD	Business Expenditure on Research and Development
BEs	Business Enterprises
BiotechCorp	Malaysian Biotechnology Corporation
BIPV	Building-integrated Photovoltaics
BS	Business Sophistication
BTP	Bioeconomy Transformation Programme
CAGR	Compound Annual Growth Rate
CIDF	Creative Industry Development Fund
CIF	Community InnoFund
CIPs	Cradle Investment Programmes
CIS	Community Innovation Survey
CO ₂	Carbon Dioxide
Cradle	Cradle Fund Sdn. Bhd.
CRDF	Commercialisation of Research and Development Fund
CTI	Coral Triangle Initiative
DAGS	Demonstrator Application Grant Scheme
DEL	Direct Exchange Line
DTSD	Diodes, Transistors and Semiconductor Devices
E&E	Electrical & Electronics
EAFM	Ecosystem Approach to Fisheries Management
EEZ	Exclusive Economic Zones

EIF	Enterprise InnoFund
EPO	Eurasian Patent Organisation
EPP	Entry Point Project
ERGS	Exploratory Research Grant Scheme
ERP	Enterprise Resource Planning
ES	Examinations Syndicate
EU	European Union
FiT	Feed-in Tariff
FOR	Field of Research
FRGS	Fundamental Research Grant Scheme
FTE	Full-Time Equivalent
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GHG	Greenhouse Gas
GII	Global Innovation Index
GIs	Geographical Indications
GLCs	Government Linked Companies
GLP	Green Lane Policy
GRI	Government Research Institutes
GT	Green Technology
HCRST	Human Capital Roadmap for Science and Technology
HEIs	Higher Education Institutions
HLIs	Higher Learning Institutions
HT	High-Technology Intensive Industry
IB	International Baccalaureate
IBS	Innovation and Business Sophistication
ICT	Information and Communication Technology
IER	Innovation Efficiency Ratio
IIUM	International Islamic University Malaysia
IMD	International Institute for Management Development
INDC	Intended Nationally Determined Contribution

Intel	Intel Sdn. Bhd.
IoT	Internet of Things
IP	Intellectual Property
IPR	Intellectual Property Rights
IRPA	Intensification of Research in Priority Areas
ITA	Investment Tax Allowance
ITU	International Telecommunication Union
IUU	Illegal, Unreported and Unregulated
KI	Knowledge Intensive Industry
KTI	Knowledge and Technology Intensive Industry
LED	Light-Emitting Diode
LOA	License, Option and Assignment
LRGS	Long Term Research Grant Scheme
MAC3	Malaysia Animation and Creative Content Centre
MAHA	Malaysia Agriculture, Horticulture & Agrotourism
MASTIC	Malaysian Science and Technology Information Centre
MDEC	Malaysia Digital Economy Corporation
MEB	Malaysia Education Blueprint
MEC	Malaysian Examinations Council
MGS	MSC Malaysia Research and Development Grant Scheme
MIDA	Malaysian Investment Development Authority
MIMOS	MIMOS Berhad
MINDEF	Ministry of Defence
MMD	Malaysian Meteorological Department
MMU	Multimedia University
MNC	Multinational Corporation
MOE	Ministry of Education
MoF	Ministry of Finance
MOHE	Ministry of Higher Education
Monash	Monash University Malaysia
MOSTI	Ministry of Science, Technology and Innovation
Motorola	Motorola Inc.

MPOB	Malaysian Palm Oil Board
MSC	Multimedia Super Corridor
MTDC	Malaysian Technology Development Corporation
MTUN	Malaysia Technical Universities
MyDAS	Malaysian (Oceanographic) Data Aggregation/ Archive System
MyIPO	Intellectual Property Corporation of Malaysia
NAC	North America
NBP	National Biotechnology Policy
NEC	National Education Code
NGOs	Non-Governmental Organisations
NIEs	East Asia's Newly Industrialised Economies
NKEAs	National Key Economic Areas
NND	National Nanotechnology Directorate
NOD	National Oceanography Directorate
Nottingham	University of Nottingham Malaysia Campus
NSDC	National SME Development Council
NSF	National Science Foundation
NSI	National Survey of Innovation
NSTP	National Science and Technology Policy
OECD	Organisation for Economic Co-operation and Development
OS	Operating System
PCF	Product Development and Commercialisation Fund
PCT	Patent Cooperation Treaty
PhD	Doctor of Philosophy
PIKOM	National ICT Association of Malaysia
PISA	Programme for International Student Association
PRGS	Prototype Research Grant Scheme
PRI	Public Research Institutes
PSPTN	Pelan Strategik Pengajian Tinggi Negara
PV	Photovoltaics
QMS	Quality Management System
R&D	Research and Development

RACE	Research Acculturation Collaborative Effort
RAGS	Research Acculturation Grant Scheme
RB	Roaming Beamer
RE	Renewable Energy
RI	Research Institutes
RU	Research Universities
S&T	Science and Technology
S2S	Sea to Space
SAR	Synthetic Aperture Radar
SCIE	Science Citation Index Expanded
SEAO	Southeast Asia & Oceania
SEB	Sarawak Energy Berhad
SEDA	Sustainable Energy Development Authority Malaysia
SEO	Socio-Economic Objectives
SIRIM	Scientific and Industrial Research Institute of Malaysia
SMEs	Small and Medium-Sized Enterprises
SMS	Short Message Services
SPM	Sijil Pelajaran Malaysia
SSCI	Social Science Citation Index
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology and Innovation
STPM	Sijil Tinggi Persekolahan Malaysia
TAF	Technology Acquisition Fund
TIMSS	Trends in International Mathematics and Science Study
TNB	Tenaga Nasional Berhad
TVET	Technical Vocational Education and Training
UAV	Unmanned Aerial Vehicle
UiTM	Universiti Teknologi MARA
UK	United Kingdom
UKM	Universiti Kebangsaan Malaysia
UKM-UTM	Universiti Kebangsaan Malaysia – Universiti Teknologi Malaysia

UM	Universiti Malaya
UM-IMR	Universiti Malaya – Institute for Medical Research
UM-MMU	Universiti Malaya – Multimedia University
UMS	Universiti Malaysia Sabah
UM-UiTM	Universiti Malaya – Universiti Teknologi MARA
UM-UKM	Universiti Malaya – Universiti Kebangsaan Malaysia
UM-UPM	Universiti Malaya – Universiti Putra Malaysia
UM-USM	Universiti Malaya – Universiti Sains Malaysia
UM-UTAR	Universiti Malaya – Universiti Tunku Abdul Rahman
UM-UTM	Universiti Malaya – Universiti Teknologi Malaysia
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNIMAP	Universiti Malaysia Perlis
UNIMAS	Universiti Malaysia Sarawak
UPM	Universiti Putra Malaysia
UPM-MARDI	Universiti Putra Malaysia – Malaysian Agriculture Research and Development Institute
UPM-UiTM	Universiti Putra Malaysia – Universiti Teknologi MARA
UPM-UKM	Universiti Putra Malaysia – Universiti Kebangsaan Malaysia
UPM-UTM	Universiti Putra Malaysia – Universiti Teknologi Malaysia
UPUM	Unit Perundingan Universiti Malaya
US/USA	United States/United States of America
USM	Universiti Sains Malaysia
USM-UiTM	Universiti Sains Malaysia – Universiti Teknologi MARA
USM-UKM	Universiti Sains Malaysia – Universiti Kebangsaan Malaysia
USM-UNIMAP	Universiti Sains Malaysia – Universiti Malaysia Perlis
USM-UPM	Universiti Sains Malaysia – Universiti Putra Malaysia
UTAR	Universiti Tunku Abdul Rahman
UTM	Universiti Teknologi Malaysia
UTP	Universiti Teknologi Petronas

VA	Value Added
WCY	IMD World Competitiveness Yearbook
WIPO	World Intellectual Property Organisation
WoS	Web of Science
WPC	Worldwide Partner Conference

APPENDIX

APPENDIX 1: NEC FIELDS OF EDUCATION AND TRAINING: STEM SUBJECTS

BROAD FIELD	NARROW FIELD		DETAILED FIELD	
4 SCIENCE, MATHEMATICS AND COMPUTING	42	LIFE SCIENCE	421 422	BIOLOGY AND BIOCHEMISTRY ENVIRONMENTAL SCIENCE
	44	PHYSICAL SCIENCES	441 442 443	PHYSICS CHEMISTRY EARTH SCIENCE
	46	MATHEMATICS AND STATISTICS	461 462	MATHEMATICS STATISTICS
	48	COMPUTING	481 482	COMPUTER SCIENCE COMPUTER USE
5 ENGINEERING, MANUFACTURING AND CONSTRUCTION	52	ENGINEERING AND ENGINEERING TRADES	521 522 523	MECHANICS AND METAL WORK ELECTRICITY AND ENERGY ELECTRONICS AND AUTOMATION
			524 525	CHEMICAL AND PROCESS MOTOR VEHICLES, SHIPS AND AIRCRAFT
			526 527	CIVIL ENGINEERING MATERIAL ENGINEERING
			541 542 543 544 545	FOOD PROCESSING TEXTILES, CLOTHES, FOOTWEAR AND LEATHER MATERIALS (WOOD, PAPER, PLASTIC, AND GLASS) MINING AND EXTRACTION APPLIED SCIENCE
58	ARCHITECTURE AND BUILDING	581 582	ARCHITECTURE AND TOWN PLANNING BUILDING	
6 AGRICULTURE AND VETERINARY	62	AGRICULTURE, FORESTRY AND FISHERY	621 622 623 624	CROP AND LIVESTOCK PRODUCTION HORTICULTURE FORESTRY FISHERIES
	64	VETERINARY	641	VETERINARY
7 HEALTH AND WELFARE	72	HEALTH	721 722 723 724 725	MEDICINE MEDICAL SERVICES NURSING AND CARING DENTAL STUDIES MEDICAL DIAGNOSTIC AND TREATMENT TECHNOLOGY
			726 727	THERAPY AND REHABILITATION PHARMACY
	76	SOCIAL SERVICES	761 762	CHILD CARE AND YOUTH SERVICES SOCIAL WORK AND COUNSELLING

Source: National Education Code Manual, Ministry of Higher Education (2010)

